ESD-TR-72-149

# PROGRESS IN ELECTRONIC SYSTEMS RESEARCH AND DEVELOPMENT TECHNOLOGY (1970)
(An Annotated Bibliography of ESD Technical Reports)

Henry F. Szemplinski, SSgt, USAF

May 1972



SCIENTIFIC AND TECHNICAL INFORMATION DIVISION
DIRECTORATE OF TECHNICAL REQUIREMENTS AND STANDARDS
HQ ELECTRONIC SYSTEMS DIVISION (AFSC)
L. G. Hanscom Field, Bedford, Massachusetts 01730

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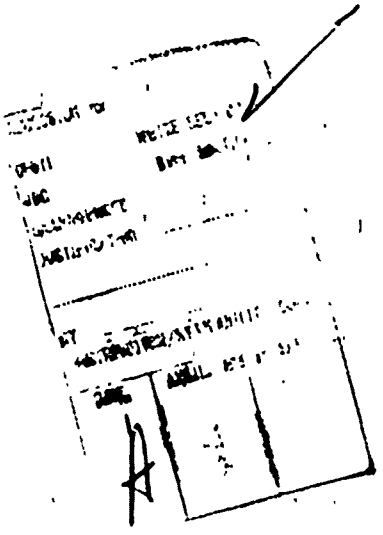

Security Classification

**DOCUMENT CONTROL DATA - R & D**

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| ORIGINATING ACTIVITY (Corporate author) | 2a. REPORT SECURITY CLASSIFICATION |
|---|---|
| Scientific and Technical Information Division<br>L. G. Hanscom Field<br>Bedford, Mass. 01730 | UNCLASSIFIED<br>2b. GROUP<br>N/A |

3. REPORT TITLE

PROGRESS IN ELECTRONIC SYSTEMS RESEARCH AND DEVELOPMENT TECHNOLOGY (1970)
(An Annotated Bibliography of ESD Technical Reports)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Bibliography - January - June 1970

5. AUTHOR(S) (First name, middle initial, last name)

Henry F. Szemplinski, SSgt, USAF

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| May 1972 | 64 | |

| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
|---|---|
| IN-HOUSE<br>b. PROJECT NO. | ESD-TR-72-149 |
| c.<br>d. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |

10 DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | Directorate of Technical Requirements and Standards, Hq Electronic Systems Division (AFSC), L. G. Hanscom Field, Bedford, Mass. 01730 |

13. ABSTRACT

The semi-annual annotated ESD bibliography includes an abstract and the AD citation number.

DD FORM 1 NOV 65 1473

Security Classification

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This technical report has been reviewed and is approved.

Carmine Pinto

CARMINE PINTO, Director
Technical Requirements & Standards

## ABSTRACT

The semi-annual annotated ESD bibliography includes an abstract and the AD citation number.

| ESD TR NUMBER | TITLE | SOURCE | DATE | CL | DDC CITATION |
|---|---|---|---|---|---|
| 70-1 | Water-Wave Effects on Radio Wave Propagation in the Ocean | Lincoln Laboratory, M.I.T. | January 1970 | U | AD 700323 |

Abstract: A sinusoidal surface profile is used to study by an exact method the effect of water waves on an electromagnetic field propogating downwards from the surface. It is assumed that the magnetic field is directed parallel to the surface corrugations. The results are presented graphically. Comparisons are made between these results and those obtained using an approximate method of Wait.

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| 70-3 | Balloon-Flight Instrumentation for Solar-Cell Measurements | Lincoln Laboratory, M.I.T. | January 1970 | U | AD 707134 |

Abstract: We have developed instrumentation which automatically measures the V-I characteristics of a number of solar cells, and transmits the resultant serialized data stream over an RF telemetry link. Our particular system was designed for 64 cells whose selection is accomplished entirely by semiconductor switching. Two-hundred-and-fifty-two points are taken on the V-I characteristic, giving detailed information on slopes as well as actual values. Measurement accuracies are 0.03 percent of full scale for voltage, and 0.1 percent for current; these do not represent attainable limits, but are simply reasonable limits for this specific application. The system described was built to calibrate solar cells on a high-altitude balloon flight, but the techniques can be used equally well for ground or satellite applications.

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| 70-6 | General Research Quarterly Technical Summary | Lincoln Laboratory, M.I.T. | February 1970 | U | AD 704573 |

Abstract: This Quarterly Technical Summary covers the period from 1 November 1969 through 31 January 1970. It consolidates the reports of Division 2 (Data Systems), Division 4 (Radar),

Division 5 (Optics), Division 7 (Engineering), and Division 8 (Solid State) on the General Research Program at Lincoln Laboratory.

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| 70-7 | Report on a Weather Radar Study for Aerospace Instrumentation Program Office (ESSI) Electronic Systems Division | Lincoln Laboratory, M.I.T. | February 1970 | U | AD 701742 |

Abstract: Presented here are the conclusions and recommendations of an ad hoc study group which investigated the problems and opportunities of providing improved airborne severe storm reconnaissance with special emphasis on airborne radar detection and surveillance of hurricanes. Study group recommendations are made in terms of what can and should be done in three epochs: by the 1970 hurricane season, by the 1971 hurricane season, and by the 1972 hurricane season. Several options are listed to allow some flexibility in choice of implementation. Discussion of the rationale is also included, and suggestions of desirable improvements in areas other than radar are made. A rudimentary radar hurricane model is presented to aid in the analysis of competing systems, and the implications on radar design of the radar requirements as presented are discussed. Throughout our deliberations we recognized the urgency of implementation of an improved radar and the constraints thereby imposed, but also saw the need of a more pervasive review by a group consisting of members from the government agencies, from the operational units, and from the several scientific and technical disciplines that should be involved in the development of national resources for improved severe storm reconnaissance, analysis, and forecasting.

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| 70-8 | The Results of the LES-5 and LES-6 RFI Experiments | Lincoln Laboratory, M.I.T. | February 1970 | U | AD 703738 |

Abstract: The RFI environment near synchronous orbital altitude in the band 255-280 MHz was measured by subsynchronous Lincoln Experimental Satellite-5 (LES-5). Similar measurements covering the band 290-315 MHz have been made by station-kept LES-6. These experiments

are a joint effort between the M.I.T. Lincoln Laboratory and the Aerospace Corporation. The nominal sensitivity of the LES-5 RFI instrument (signal-noise) corresponds to Earth-surface transmitter EIRP of 50 to 100w (RHCP) near 255 MHz. LES-5 sensitivity is 20 db poorer toward the high end of its band (280 MHz). The nominal sensitivity of the LES-6 RFI instrument correspondes to EIRP of 10 to 25 w (RHCP) across the band 290-315 MHz. The success of the LES-5 and -6 RFI experiments show that it is practical to monitor the level of activity in selected bands of the communication spectrum, throughout wide portions of the Earth from synchronous orbit. This capability may be useful in the management of portions of the electromagnetic spectrum where frequency allocations are at a premium.

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| 70-9 | Research and Development of High Speed Processor Arrays | Philco-Ford Corporation, Microelectronic Division (under subcontract to Lincoln Lab., M.I.T. | December 1969 | U | AD 702687 |

Abstract: This report describes program progress for the first four interim periods of a research and development program directed toward the development of high density, high performance, complex digital arrays and their application in system feasibility studies of a high speed Central Processor. An important task of this program was to establish subnanosecond-minimum power ECL microcircuit designs which could be used as effective building blocks for the Processor Arrays. This task required the design, fabrication and evaluation of an array test chip containing different microcircuit designs. The task was accomplished; specific small geometry gate and reference bias microcircuits (gate power dissipation was nominally 15 mW, including complementary outputs) were selected and utilized in the design of an 80-gate Processor Master Array Chip. Functioning high speed 256-bit Read Only Memory Arrays were successfully fabricated. A flexible technique for programming these ROM's at the chip level was developed and demonstrated. Yield improvement studies were conducted. This effort included an investigation of the applicability of the CDI process

to high speed ECL. It also included the design and evaluation of a complex Multilevel Process Test Chip for characterizing and monitoring multilevel interconnection processes and structures. Techniques for multichip assembly of high speed LSI chips were investigated. In particular, the fundamental processes for solder reflow face-down bonding and aluminum beam lead technology were established. All photomasks employed during the program were designed at M.I.T. Lincoln Laboratory using computer aid.

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| 70-10 | Effect of External Stress on Remanence Ratios and Anisotropy Fields of Magnetic Materials | Lincoln Laboratory, M.I.T. | March 1969 | U | AD 703524 |

Abstract: Changes in shape of the hysteresis loops of magnetic materials with compressive stress applied parallel to the magnetic field have been studies both theoretically and experimentally. From a model of a single independent grain, the results of theory suggest that for materials with negative anisotropy, the $\lambda_{100}$ magnetostriction constant controls the effects of both the remanence ratio and anisotropy field. When the anisotropy is positive, the $\lambda_{111}$ constant is predominant. For a single-crystal specimen of $Y_3Fe_5O_{12}$, quantitative agreement with the theory was obtained from measurements carried out on a hysteresigraph. Polycrystalline samples of $Y_3Fe_5O_{12}$, $Y_{1.4}Ca_{1.6}V_{0.5}In_{0.5}Fe_{3.7}O_{12}$, and $Y_3Mn_{0.1}Fe_{4.9}O_{12}$ were examined in a more qualitative manner and these results were also in accord with theory.

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| 70-11 | A Thermodynamic Investigation of the Compounds $In_3SbTe_2$, InSb, and InTe | Lincoln Laboratory, M.I.T. | January 1967 | U | AD 701240 |

Abstract: The heats of formation at 78°, 195°, and 273°K of the ternary compound $In_3SbTe_2$ based on the elements and based on the binary compounds InSb and InTe have been measured. The heats of formation at these temperatures of the binary compounds InSb and InTe based on the elements have also been determined. Heat contents and free energies of the three compounds have been calculated from 0° to 800°K. The free energies of formation, heats of formation,

and entropies of formation at 298°K have also been calculated. The results show that the ternary compound is metastable with respect to InSb and InTe below 696°K, but is stable above that temperature. The weaker bonding of $In_3SbTe_2$ results in a positive entropy of formation which with increasing temperature makes increasing negative contributions to the free energy and above 696°K renders the compound stable.

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| 70-12 | Iterative Sequential Decoding | Lincoln Laboratory, M.I.T. | February 1967 | U | AD 703488 |

Abstract: It is shown that use of a two-stage decoding procedure consisting simply of an inner stage of block decoding and an outer stage employing a single sequential decoder does not result in an improvement in the computational overflow problem for the sequential decoder. Improvement can, however, result from use of multiple sequential decoders or use of a single sequential decoder with appropriate scrambling. Although the performance improvement resulting from application of these techniques to the additive white Gaussian noise channel is not significant, implementation and rate advantages make iterative sequential decoding techniques worth pursuing. In particular, with these techniques, a sequential decoder for a binary symmetric channel can be used regardless of the physical channel characteristics. Such a "universal" decoder is expected to be both simple and capable of high rate operation.

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| 70-13 | Space-Filling Curves: Their Generation and Their Application to Bandwidth Reduction | Lincoln Laboratory, M.I.T. | July 1968 | U | AD 703413 |

Abstract: This paper introduces a class of finite-state algorithms which characterize self-similar space-filling curves. The curves enable one to continuously map a line onto an N-dimensional cube, and find application in compressing the bandwidth of arbitrary waveforms.

The bandwidth compression is effected in return for an increased susceptibility of the signal to perturbations. The algorithms are represented in a diagrammatic form which enables one to convert the N coordinates of a point in a cube into a single number representing the distance along a space-filling curves, or vice-versa, merely by visual inspection. The diagrams are always finite in size and may be constructed by following a rather simple numerical procedure.

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| 70-14 | Magnetic-Anisotropy and Magnetostriction Constants of Substituted Lithium Ferrites at 300°K | Lincoln Laboratory, M.I.T. | January 1969 | U | AD 703756 |

Abstract: Room temperature measurements of magnetic anisotropy constants $K_1$ and $K_2$ and magnetostriction constant $\lambda_{100}$ and $\lambda_{111}$ on single crystal lithium ferrites containing Al, Ti, Ga, Zn, In, Co, and Mn have been carried out by means of ferrimagnetic resonance techniques at 5.8 GHz. From the measurements of $K_1$, it appears that only cobalt has a significant effect on anisotropy, in accord with earlier works on other spinels. From the magnetostriction measurements, it is concluded that manganese has a significant effect on $\lambda_{100}$ and $\lambda_{111}$, where changes in the signs of both constants occur as the amount of substitution is increased. The effect of manganese substitutions is shown to also exist in the yttrium iron garnet system.

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| 70-15 | Brillouin Scattering Study of Acoustic Attenuation in Fused Quartz | Lincoln Laboratory, M.I.T. | February 1969 | U | AD 703759 |

Abstract: The velocity and attenuation of 27-28 GHz longitudinal hypersonic waves in fused quartz have been measured for temperatures between 80 and 600°K. The data are obtained using high-resolution signal-averaging techniques of thermal Brillouin spectroscopy. The velocity, or Brillouin shift, is found to increase with temperature at a rate of $\sim 0.011\%/^{\circ}K$ throughout the range. The attenuation, or linewidth, goes throughout a pronounced peak at a temperature of $\sim 130^{\circ}K$. This sort of behavior usually indicates a structural relaxation

mechanism for the hypersonic damping, as has been suggested for previous ultrasonic measurements in fused quartz. However, it is demonstrated that an anharmonic model involving three-phonon interaction can explain the absorption data with fewer adjustable parameters, which have better physical justification.

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| 70-16 | Derivation of a Quasiparticle Transport Equation for an Impure Fermi Liquid at Low Temperatures | Lincoln Laboratory, M.I.T. | April 1969 | U | AD 703491 |

Abstract: The problem of the linear response to a longitudinal driving field of low frequency and long wavelength for a system of interacting fermions at low temperatures in the presence of dilute random impurities is studied by the use of temperature Green's function techniques. A quasiparticle distribution function for this system is defined and its connection with induced quantities, such as the particle and current densities, is determined. It is shown that this distribution function satisfies a transport equation with a nondissipative part of the form suggested by Landau and a dissipative part made up of the sum of impurity and interparticle scattering terms. The quantities entering the theory, among which are the coefficients of the transport equation, are determined to all orders in the interparticle and impurity interaction strengths, and, where appropriate, to first order in the impurity density. Many of these results are obtained from the development and use of a generalization to an impure system of Eliashberg's work on pure Fermi liquids.

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| 70-17 | Roundoff Noise in Floating Point Fast Fourier Transform Computation | Lincoln Laboratory, M.I.T. | July 1969 | U | AD 703354 |

Abstract: A statistical model for roundoff errors is used to predict output noise-to-signal ratio when a fast Fourier transform is computed using floating point arithmetic. The result, derived for the case of white input signal, is that the ratio of mean-squared output noise to mean-squared output signal varies essentially as $\nu = \log_2 N$ where N is the number of points transformed.

This predicted result is significantly lower than bounds previously derived on mean-squared output noise-to-signal ratio, which are proportional to $v^2$. The predictions are verified experimentally, with excellent agreement. The model applies to rounded arithmetic, and it is found experimentally that if one truncates, rather than rounds, the results of floating point additions and multiplications, the output noise increases significantly (for a given v). Also, for truncation, a greater than linear increase with v of the output noise-to-signal ratio is observed; the empirical results seem to be proportional to $v^2$, rather than to v.

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| 70-18 | Parameters of Microstrip | Lincoln Laboratory, M.I.T. | September 1969 | U | AD 703489 |

Abstract: The program computes the capacitance, effective permittivity, characteristic impedance and phase velocity of single strips, and of normal modes of coupled pairs of strips, in an approximation in which the longitudinal components of the fields and the thickness of the conducting strips are neglected. Within this model, the inhomogeneous dielectric is treated in rigorous manner.

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| 70-19 | Seasonal Variation of the F-Region Ion Composition | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 703492 |

Abstract: Thomson scatter observations at a wavelength of 23 cm are described that supplement earlier ionospheric studies made at the Millstone Hill Radar of the region 130-230 km. By making certain reasonable assumptions about the altitude dependence of the electron and ion temperatures, it has been possible to recover from the observations the ratio of atomic ions ($O^+$) to molecular ions ($O_2^+$ or $NO^+$) in this region. A marked seasonal variation is found with $O^+$ extending to lower altitudes in winter than in summer. The results suggest a seasonal variation of the abundance of neutral atomic oxygen that has not yet been detected in rocket-borne ion mass spectrometer measurements.

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| 70-20 | An On-Line Data Recording System | Lincoln Laboratory, M.I.T. | July 1969 | U | AD 703490 |

A. stract: A relatively simple system for recording experimental data from an optical spectrometer has been built and operated. The data are transmitted by telephone at a maximum rate of about four points/sec to a central computing facility where they are recorded on magnetic tape. Several simultaneous users can be accepted. A brief description of the interface between the experiment and the computing facility is presented.

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| 70-21 | Residual Impurities in High-Purity Epitaxial GaAs | Lincoln Laboratory, M.I.T. | September 1969 | U | AD 703487 |

Abstract: Results of mass spectrographic analyses with detection limits down to $1 \times 10^{15} cm^{-3}$ for samples of epitaxial GaAs with total ionized impurity concentrations as low as $7.6 \times 10^{13} cm^{-3}$ ($\mu_{77°K} = 200{,}000\ cm^2/V\text{-sec}$) are reported.

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| 70-26 | Studies of Display Symbol Legibility: XXII. The Relative Legibility of Four Symbol Sets Made with a Five by Seven Dot Matrix | MITRE Corporation, Bedford, Mass. | March 1970 | U | AD 704136 |

Abstract: Legibility comparisons were made amoung four 5 x 7 dot fonts. The four symbol fonts were shown under nearly optimal viewing conditions to one group of operators and under degraded viewing conditions to a second group of operators. The results showed that no one symbol set was significantly superior in legibility to any of the other sets. It was concluded that new symbols designs are needed to improve the legibility of present 5 x 7 dot symbol sets.

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| 70-27 | The Development of a Computer-Directed Training Subsystem and Computer Operator Training Material for the Air Force Phase II Base Level System | System Development Corp. | November 1969 | U | AD 702529 |

Abstract: This report describes a study concerned with the design, development and evaluation of an integrated Computer-Directed Training Subsystem (CDTS) for the Air Force Phase II Base Level System. The development and evaluation of a course to train computer operators of the Air Force Phase II Base Level System under CDTS control is also described. Detailed test results for validation of the computer operator course and Formal Qualification testing of the CDTS are presented. Conclusions and recommendations with respect to the current CDTS recommendations for additional capabilities and further implications are discussed.

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| 70-29 | Equalization Studies for the PAM Digital Modem | MITRE Corporation, Bedford, Mass. | March 1970 | U | AD 704137 |

Abstract: This paper is a revision of WP-2888. It reviews the present state-of-the-art techniques of narrowband (4KHz) wireline equalization for PAM signals. Two basic minimization techniques are discussed. Related derivations and proofs are included. In addition to linear distortion, the problems due to phase jitter are mentioned as areas of possible future research.

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| 70-30 | Adaptive Signal Processing for Ionospheric Distortion Correction | MITRE Corporation, Bedford, Mass. | March 1970 | U | AD 704135 |

Abstract: Ionospheric distortions limit the usable signal bandwidth of HF over-the-horizon parths. By measuring the transfer function of the path and correcting for it in real time, improved

bandwidth capability results. To determine the feasibility of such a real-time correction technique, data has been gathered on an HF link operated by Stanford University and analyzed by computer at MITRE. A non-real-time computer simulation of a correction technique has shown that for the bandwidths analyzed, the correction technique is feasible and that the correction will not deteriorate significantly for several seconds.

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| 70-32 | Description of Computer Programs for the Analysis and Presentation of Trade Winds Data | Syracuse University Research Corporation | December 1969 | U | AD 702530 |

Abstract: An investigation of the Trade Wind Duct was carried out from March 6 through March 25, 1969 in the Northern part of the Caribbean Sea. An instrumented aircraft was used to record meteorological and radio refractivity data in digitized format for computer analysis. In addition, extensive radio-sonde data was included in the analysis to support the aircraft measurements and provide a basis for weather analysis. In order to assimilate, process and present such a large amount of data it was imperative that machine processing be used. The following report describes the vari programs which were used in the analysis and presentation of the data. A ray-tracing program was also developed to analyze radio wave propagation in relation to Trade Wind Duct characteristics. This program has the advantage that horizontal changes in the Duct can be included. Most ray-tracing programs assume that the vertical variation of refractivity is spherically stratified.

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| 70-33 | Solid State Research | Lincoln Laboratory, M.I.T. | February 1970 | U | AD 707135 |

Abstract: This report covers in detail the solid state research work at Lincoln Laboratory for the period 1 November 1969 through 31 January 1970. The topics covered are Solid State Device Research, Materials Research, and Physics of Solids.

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| 70-34 | Very Long Baseline Interferometry as a Means of Worldwide Time Synchronization | Lincoln Laboratory, M.I.T. | February 1970 | U | AD 707134 |

Abstract: Extraterrestrial radio waves from sources of small angular size can be used to synchronize clocks at two receiving sites to a high degree of precision. Radio star signals, together with time identification, are recorded on magnetic tape. Tapes are subsequently processed on a digital computer to obtain the synchronization error between the two clocks at the time of observation. The ultimate limit to the precision of the method is the knowledge of the relative signal delay in the atmosphere and ionosphere.

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| 70-35 | Optimum CFAR Detection Tests for Fluctuating and Non-fluctuating Signals | Lincoln Laboratory, M.I.T.* | December 1967 | U | AD 867083 |

Abstract: Two general methods of approach are described to the derivation of optimum CFAR tests for detection of fluctuating and non-fluctuating signals in the presence of noise whose intensity is unknown and non-uniform among resolution cells. A variety of detection tests is derived by these methods. A simulation program is described which evalutes performance of such methods, and sample results are given. The methods defined herein are motivated by possible application to detection of targets in non-uniform chaff or other types of non-uniform clutter.

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| 70-38 | Laser Beam Trapping and Nonlinear Interactions in Semiconductors | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 704461 |

Abstract: A simple description of thermal beam trapping is presented, together with the possible application of this effect to produce a CW or quasi-CW Raman or Brillouin oscillator.

*in cooperation with Technology Service Corp., Ca.

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| 70-39 | Signal Processing by the Bat - Myotis Lucifugus | Lincoln Laboratory, M.I.T. | September 1969 | U | AD 704619 |

Abstract: Observation of cochlear microphonics in the bat Myotis lucifugus shows (as expected) that if the frequency modulation of vespertilionid echolocating cries is used for pulse compression, the compression is not accomplished in the middle or the inner ear. In order to improve the signal-to-noise ratio in a frequency-independent way, the microphonics were observed with the help of a heterodyne technique that may be useful in other investigations of cochlear microphonics. The experiments imply that if vespertilionids do use pulse compression, they use neural storage of the outgoing signal. The relation of this conclusion to some earlier suggestions about bat sonar has been indicated.

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| 70-40 | Some Problems in the Theory of Guided Microsonic Waves | Lincoln Laboratory, M.I.T. | May 1969 | U | AD 704460 |

Abstract: The wave equation for elastic waves in an isotropic solid generally in Cartesian and in circular cylindrical coordinates. The solutions are applied in the study of a variety of guiding structures of circular and rectangular symmetry. In general, the wave functions do not satisfy the boundary conditions, but in special cases they do. From a study of these special cases it is possible to arrive at some useful results and to elicit general principles which give some insight into the behavior of wave-guides in general. The results and observations obtained are compared and contrasted, where appropriate, with corresponding results for electromagnetic waveguides.

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| 70-41 | Optimum Radar Signal-Filter Pairs in a Cluttered Environment | Lincoln Laboratory, M.I.T. | April 1969 | U | AD 704622 |

Abstract: In a recent paper on radar detection in clutter, the authors stated that the signal-to-interference ratio $\rho_{cf}$ (u) obtained with the signal $u$ and its optimum filter can have

stationary points which are not stationary points of $\rho_{mf}(u)$, the signal-to-interference ratio obtained with $u$ and its matched filter, even when the clutter distribution in range and Doppler is symmetric. This letter strengthens this statement and exhibits an example to support it. The stronger statement is the following: Even for symmetric clutter distributions, the global maximum of $\rho_{cf}$ can exceed the global maximum of $\rho_{mf}$.

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| 70-42 | X-Ray Diffraction Studies on $Zn_3As_2$ and $Cd_3As_2$ at High Pressure | Lincoln Laboratory, M.I.T. | July 1969 | U | AD 704458 |

Abstract: The effect of pressure on the structures of $Cd_3As_2$ and $Zn_3As_2$ has been studied by measurements at room temperature in diamond anvil X-ray diffraction cameras from atmospheric pressure to ~ 140 kbar. Both compounds transform at high pressure to structures which have been indexed as trigonal, but with cell dimensions about twice those reported in the literature. The possibility of existence of cubic intermediate phases is suggested. The volume compressibilities for the $Cd_3As_2$ and $Zn_3As_2$ phases have been determined. Diffraction patterns on samples of $Cd_3As_2$ are in essential agreement with X-ray pressure camera results, but those for $Zn_3As_2$ samples could not be satisfactorily indexed.

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| 70-43 | Velocity and Attenuation of Hypersonic Waves in Liquid Nitrogen | Lincoln Laboratory, M.I.T. | May 1969 | U | AD 704624 |

Abstract: High resolution thermal Brillouin scattering techniques have been used to measure the velocity and damping of sound in liquid nitrogen in the 3-5Ghz range. The measurements were carried out along the saturated vapor line from the triple point to the normal boiling point. No deviation from previous ultrasonic values of velocity or the classical $v^2$ attenuation is observed at these frequencies. Thus acoustic dispersions due to the 2 GHz relaxation frequency of the internal molecular vibration is completely negligible.

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| 70-44 | A Beam-Lead Substrate Package for a Six-Stage TTL Shift Register | Lincoln Laboratory, M.I.T. | May 1969 | U | AD 704422 |

Abstract: Commercial integrated circuit chips have been incorporated into a new type of final package which is called a beam-lead substrate. The technique utilizes glass or ceramic substrates with interconnexion metallization and the beam cantilevered over holes in the substrate. The commercial dice are inserted into the holes and bonded to the overhanging beams. TTL chips when incorporated into a six-stage shift register utilizing this type of package show a temperature rise of approximately 0.5°C/W when the package is attached to a heat sink, and 14.3°C/W when the circuit is operated suspended in air. The performance characteristics of the chips are unchanged from the manufacturer's specifications after incorporation into the package. The beam-lead substrate package is made by depositing the interconnexion and beam-lead metallization on the substrate, and etching suitable holes under the beams. Chromium/platinum/gold and molybdenum/gold metallizations were evaluated. Sputtered molybdenum/gold was chosen as the best metallization system for this application because of the excellent bondability of the beams after final processing.

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| 70-45 | A State-Space Bandwidth Constraint for Problems in Waveform Design | Lincoln Laboratory, M.I.T. | May 1969 | U | AD 704625 |

Abstract: In this correspondence we review some of the difficulties associated with the commonly used bandwidth constraints in the time domain. Then we derive a constraint in state-space, which guarantees that the signal design will result in a waveform having a certain percentage of its energy within a specified frequency band.

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| 70-46 | Detection of Conjugate Photoelectrons at Millstone Hill | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 704626 |

Abstract: Photoelectrons arriving in the F region from the conjugate point have been detected at Millstone Hill during the winter night, by means of Thomson scatter observations of the plasma lines that appear in the signal spectrum. During winter, when the solar zenith angle $\chi_c$ at the conjugate point is less than 100° throughout the night, the plasma lines are continuously present, provided that the local plasma frequency exceeds 4.0MHz. For a few days in the spring the lines disappear for a period around midnight when $\chi_c \geq 106°$. These observations confirm that photoelectrons can escape from one hemisphere into the other for L values as large as 3.2. The arriving flux appears to be too weak, however, to give rise to significant excitation of the 6300-A line of atomic oxygen (J. F. Noxon, personal communication), which suggests that direct excitation may not be the main cause of the large predawn enhancements seen elsewhere.

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| 70-47 | Polaron Cyclotron Resonance in CdTe | Lincoln Laboratory, M.I.T. | September 1969 | U | AD 704529 |

Abstract: Measurements have been made of the field dependence of the cyclotron mass of conduction-band electrons in the moderately polar semiconductor CdTe. These measurements, when compared with predictions deduced from the Fröhlich Hamiltonian by the novel variational calculation to be described, give the first quantitative experimental test of large-polaron theory.

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| 70-48 | Determination of F-Region Vertical Drifts at Millstone Hill | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 704531 |

Abstract: Thomson scatter observations of the F-region at altitudes between 450 and 900 km are described; from them the bulk vertical velocity of the ambient electrons can be determined. These measurements were made possible by the construction of a new spectrum analyzer; they supplement earlier established programs to measure F-region densities and temperatures at Millstone Hill. The uncertainty in the results varies both with time of day and with altitude

but is of the order of $\pm$ 5 m/sec. Sample results are presented which show evidence of (1) thermal expansion and contraction of the layer and (2) oscillatory fluctuations attributed to traveling ionospheric disturbances.

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| 70-49 | Microsound Components, Circuits, and Applications | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 704632 |

Abstract: Surface acoustic wave components have been realized which perform the functions of transduction, amplification, and coupling. Applications are suggested which make use of these components. Exploratory work in connection with surface acoustic waveguides suggests the feasibility of acoustic analogs of conventional microwave transmission line (microsound) components on the surface of crystal and substrates. These microsound transmission lines, hybrids, and directional couplers interconnect microsound transducers, amplifiers, isolators, and phase shifters to form microsound circuits capable of auto-correlation, Fourier transformation, and cross correlation functions. Compatible component configurations are proposed and evaluated which perform these basic functions. The anticipated difficulties with their realization are discussed and the current status of critical problems including the epitaxial growth of thin films and submicron etching procedures will be given. Several circuits capable of performing correlation functions are given.

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| 70-50 | Far-Infrared Recombination Radiation from Impact-Ionized Shallow Donors in GaAs | Lincoln Laboratory, M.I.T. | September 1969 | U | AD 704633 |

Abstract: Radiation corresponding to transitions from excited shallow donor states and from conduction-band states to the donor ground state has been observed in impact-ionized GaAs at temperatures near 4.2°K. Spectral measurements show a main peak at a wavelength of 282$\mu$ (4.4 meV), corresponding to a $2p \rightarrow 1s$ transition, and a broader continum extending to higher photon energies. A total radiated power of $10^{-7}$W has been measured corresponding to an external quantum efficiency of about $10^{-6}$.

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| 70-51 | Optical Observation of Magnetic-Field-Induced Spin Alignment in Antiferromagnetic EuTe | Lincoln Laboratory, M.I.T. | September 1969 | U | AD 704634 |

Abstract: The effects of spin alignment induced by a large external magnetic field have been observed in the optical reflectivity spectra of antiferromagnetic EuTe at 1.5K. By comparison with the reflectivity spectra of ferromagnetic EuO, EuS, and EuSe, we conclude that we have observed the transition from an antiferromagnetic superlattice band splitting to the ferromagnetic exchange splitting that occurs with complete spin alignment at $H \sim 80$ kOe.

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| 70-52 | Theory of Surface Plasmon Excitation in Low-Energy Electron Diffraction and in Photoemission | Lincoln Laboratory, M.I.T. | November 1969 | U | AD 704636 |

Abstract: A theory of inelastic scattering of electrons by surface plasma oscillation is presented for low-energy electron diffraction and photoemission. The calculations give results which lend quantitative support to the interpretations of some prominent inelastic effects as due to surface plasmon excitation in recent experiments by Lander and Morrison in low-energy electron diffraction and by Smith and Spicer in photoemission.

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| 70-53 | VHF Antenna System for Aircraft | Lincoln Laboratory, M.I.T. | March 1970 | U | AD 705170 |

Abstract: Presented are the initial results of a theoretical investigation of crossed-slot antenna elements arrayed on an aircraft to provide communications with satellites in the 225 to 400 MHz frequency range. Calculations indicate that two four-element array antennas can approximate the desired performance of covering the hemisphere above the aircraft with more than 6 dB directive gain. Including the polarization loss between the eliptically polarized aircraft antenna and the circularly polarized satellite antenna, coverage is provided over about 90 percent of the desired area.

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| 70-55 | Optimal Mismatched Filter Design for Radar Ranging, Detection and Resolution | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 706397 |

Abstract: In a multiple target environment a radar signal processor often uses weighting filters which are not necessarily matched to the transmitted waveform. In this paper expressions for the mean-squared range-estimation error, the detection signal-to-noise (SNR) and the effects of sidelobes are derived in terms of the impulse response of an arbitrary mismatched filter. It is desired to find that impulse response which results in the minimum range estimate variance subject to preassigned constraints on the sidelobes and the detection SNR. This optimization problem is first formulated in state-space in which the optimal control law is sought. Pontryagin's maximum principle is used to obtain necessary conditions for the optimum impulse response, from which it is possible to deduce the structure of the optimum filter. Certain mathematical details which detract from the rigor of the time domain formulation are resolved by formulating the problem in the frequency domain and applying Hilbert Space techniques. It is shown that for the problem of detecting the radar target and estimating its range, the optimum filter is a modified transversal equalizer. If only the detection function is to be performed the optimum filter reduces to the transversal equalizer. This establishes the optimality of this important practical device as the solution to the radar detection problem in a multiple target environment. The tap weights and spaces of the delay line as well as certain other parameters upon which the solution depends can be found by solving a non-linear programming problem. Numerical results are given for an interesting class of transmitted waveforms which shows the tradeoffs of the various filter parameters.

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| 70-60 | Radio Refractivity and Meteorological Data Plots from Radiosonde Launches Trade Winds - March 1969 | Syracuse University Research Corporation | January 1970 | U | AD 702929 |

Abstract: Radiosonde data were collected from the Northern part of the Caribbean Sea, during the period 6 March through 26 March 1969. Stations were selected to emcompass the area wherein instrumented aircraft measurements were made of meteorological and radio refractivity parameters.

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| 70-65 | Survey and Analysis of Major Computing Operating Systems (OS Survey) | Comptre Corporation | January 1970 | U | AD 704138 |

Abstract: The major contemporary computer operating systems were surveyed and analyzed for the purpose of defining a functional classification structure applicable and common to the executive/control function of all operating systems. In addition, performance parameters were developed for each of the common functions and the technical feasibility of various operating system validation techniques were assessed. While it was determined that an automated general purpose validation system is technically feasible, it is impractical at the present time.

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| 70-71 | Transcutaneous Special Blood-Flowmeter | Lincoln Laboratory, M.I.T. | March 1970 | U | AD 707136 |

Abstract: A proposed instrument capable of measuring quantitative blood flow in man is described. The techniques utilized involve no trauma or hazard to the patient and being transcutaneous, are suitable for clinical use. This report reviews the present status of transcutaneous blood-flowmeters, furnishes a brief tutorial on basic ultrasonic principles and limitations relevant to biological usage, considers the theoretical bases for the proposed techniques, and translates these into a prototype system. Finally, recommendations for initiating a program to devise such an instrument are presented.

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| 70-74 | Some Applications of the Thermal Single-Determinant Approximation | Lincoln Laboratory, M.I.T. | January 1969 | U | AD 707578 |

Abstract: A new extension of Hartree-Fock theory to non-zero temperature, T, namely the Thermal Single-Determinant Approximation (TSDA)--based on the variational principle of statistical mechanics--has been applied to a model of a crystal of widely separated hydrogen atoms.

It is found that, in this TSDA, solutions to the equations of stationarity of the free energy consist of one-electron functions which are either spatially extended (like Bloch functions), or localized. Whereas it appears that in the standard thermal Hartree-Fock approximation (THFA) only extended solutions are possible (at finite atomic separation). Furthermore, in the TSDA at $T \neq 0$ the localized solutions give a lower free energy that that corresponding to the extended solutions, and the latter is less than or equal to the free energy in the THFA. As far as we know, this is the first calculation in which a strictly variational requirement has rejected extended one-electron functions in favor of localized functions for a crystal.

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| 70-75 | The Role of Oxygen Pressure in the Control and Measurement of Composition in 3d Metal Oxides | Lincoln Laboratory, M.I.T. | April 1969 | U | AD 707567 |

Abstract: The 3d metals from Sc through Zn exhibit a variety of valence states in their oxides. More than 35 oxides exist for these ten metals. The published thermodynamic data for the 3d metal oxides are summarized in extended pressure-composition phase diagrams for 1000°K, which given the range of oxygen pressure over which each compound is stable. The deviation from stoichiometric composition is also shown in the diagrams and is summarized in a table which relates this range to the range of oxygen pressure over which each compound is stable. It is observed that in general the range of oxygen pressure varies inversely with the width of the composition range. Oxygen pressure uniquely determines the compound formed and the deviation from the ideal pressure uniquely determines the compound formed and the deviation from the ideal stoichiometry for each metal, and so it is important in preparing oxides to control this pressure. Methods of controlling and measuring this pressure over about 50 orders of magnitude are discussed. Some techniques for synthesis and crystal growth of these oxides are summarized. The limitations of chemical analysis are outlined, and other techniques are described by which the composition can be more accurately measured.

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| 70-76 | Structural, Electrical and Magnetic Properties of Vacancy Stabilized Cubic TiO and VO | Lincoln Laboratory, M.I.T. | April 1969 | U | AD 707565 |

Abstract: The cubic components $TiO_x$ and $VO_x$ have a wide homogeneity range with x varying from about 0.75 to 1.30, and a total vacancy content as high as 20%. They are interesting because of the continuous change of structural, chemical, physical and electrical properties across this homogeneity range. Previous work on these compounds is summarized briefly showing many disagreements in the published data. This paper presents a consistent body of data on the lattice parameter, density, electrical resistivity $\rho$, Seebeck coefficient $\alpha$, and magnetic susceptibility $\chi_M$ for about thirty carefully characterized samples of each.

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| 70-77 | Evidence for a Continuous Sequence of Structures in the Bi-Te System | Lincoln Laboratory, M.I.T. | April 1969 | U | AD 707580 |

Abstract: Extending our earlier work, Bi-Te samples have been synthesized at intervals of 1 at % between 50 and 57 at % Te and X-ray powder diffraction patterns taken at 25°C. The hexagonal Miller indices for all samples can be represented by a single generalized set. For each member of this set, the h and k-indices are constants while the $l$ -index is a fixed linear function of two integers, $s$ and $t$, characteristic of the composition and annealing temperatures. The structures are therefore closely related, being the same in two directions but differing in the third along the $c$-axis. The number of atomic layers along the $c$-axis per unit cell is $3s$. The parameters characterizing the structures were obtained by minimizing the function

$$\sigma(\Sigma\Delta 2\theta) = \left\{ \sum_{i=1}^{M} (2\theta_{i,cal} - 2\theta_{i,obs})^2 / (M-2) \right\}^{\frac{1}{2}}$$

A fit was considered adequate only if the associated value of $\sigma$ was 0.017° or less. Adequate fits are obtained for each composition and annealing temperature only for a narrow range of values for $s/t$, (a) that generally contains no small integral values of s and t and therefore no small $c_0$ values, and (b) the center of which moves from 3.91 to 4.53 as the composition varies from 50.0 to 57.0 at Te%. Although the parameters $c_0$, $s$ and $t$ vary irregularly with composition $a_0$, $c_0/s$ and $s/t$ vary smoothly. It appears likely that there is a continuous sequence of distinct, though closely related, structures in the 50-57 at %Te interval of Bi-Te stsrem at 450°C. Thus one may very well have a range of solid solution in the thermodynamic sense, that, contrary to the usual case, is not characterized by a single structure.

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| 70-78 | Signal Processing Hardware for General Purpose Computers | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 707829 |

Abstract: The increased use of digital filtering and fast Fourier transform algorithms has raised the questions of how efficiently present-day general purpose computers perform these algorithms. In this paper, several different computer structures are examined in this respect and compared with conventional structures.

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| 70-79 | Inversion-Asymmetry and Warping-Induced Interband Magneto-Optical Transitions in InSb | Lincoln Laboratory, M.I.T. | October 1968 | U | AD 707249 |

Abstract: Direct interband magneto-optical transitions have been observed at k=0 in InSb using the reflection technique at 1.5°K. In addition to the normal spectral structure associated with allowed transitions, some strong features have been observed associated with "extra" transitions produced both by warping and the linear-in-k splitting of the valence band of InSb. An unambiguous assignment of the origin of these transitions has been made by a study of the anisotropy of the spectra with the magnetic field H in the (110) crystal plane

using left and right circularly polarized light. With the allowed and extra transitions, we can determine the relative energies of the first five valence-band magnetic energy levels. By fitting these, and the strengths of the extra transitions, we determine Luttinger's warping parameter $(\gamma_3-\gamma_2)$ and the Dresselhaus inversion-asymmetry parameter C. In addition, it is necessary to retain Luttinger's parameter $q$, which normally has been assumed to be zero. This quantity is present in the effective-mass Hamiltonian when there is a magnetic field and spin-orbit interaction. We find: $(\gamma_3-\gamma_2)=1.2\pm15\%$, $q=0.4\pm50\%$, and $C=6.6\times10^{-4}$ a.u. $\pm30\%$. This value of C is about 4.5 times smaller than an erroneous value published previously.

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| 70-80 | Intermodulation Product and Switching Noise Amplitudes of a p-i-n Diode Switch in the UHF Band | Lincoln Laboratory, M.I.T. | February 1969 | U | AD 707830 |

Abstract: This correspondence describes some measurements of intermodulation product and switching noise amplitudes at UHF in a p-i-n diode switch.

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| 70-81 | Longitudinal Sectional Mode Analysis of Dielectrically Loaded Rectangular Waveguides with Application to Phase Shifter Design | Lincoln Laboratory, M.I.T. | March 1969 | U | AD 707584 |

Abstract: The structure consisting of an E-plane dielectric slab partially filling a rectangular waveguide is examined with attention on those higher order mode propagation characteristics that are relevant to the design of nonreciprocal remanence ferrite phase shifters. The validty of the model is established by introducing experimental comparison in the form of VSWR measurements for both pure dielectric loading and an actual composite ferrite phase shifter. Emphasis is placed on the consideration of possible mechanisms for the elimination of $LSE_{11}$, $LSM_{11}$, and $LSE_{12}$ modes, since certainly the first, most probably the second, and quite possibly the third

will propagate in a practical device. Experimental vertification of theoretical predictions is established and phaser design guidelines are drawn. Some additional topics, such as slab-corner chamfering and the effect of the switching wire, are included for completeness.

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| 70-82 | Polarons Bound in a Coulomb Potential. I. Ground State | Lincoln Laboratory, M.I.T. | May 1969 | U | AD 707818 |

Abstract: We introduce a trial function for the ground state of a polaron bound in a Coulomb field which yields, in the experimentally important ranges of Coulomb binding and polaron coupling constant $\alpha$ lower energies than have previously been reported. In distinction from earlier calculations, our ansatz gives, additionally, the correct polaron mass renormalization in the weak-binding-weak-coupling limit. For the very weakly bound polaron, our trial function is not continuous in $\alpha$ ; a discontinuity occurs at $6.25 \ll \alpha < 6.5$. We speculate that this discontinuity is associated with a long conjectured breakdown of perturbation theory for the free-polaron ground state near $\alpha = 6$. Methods for evaluating the perturbed bound-polaron ground-state energy for weak coupling are discussed.

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| 70-83 | Absolute Specular Reflectance Measurements of Highly Reflecting Optical Coatings at 10.6$\mu$ | Lincoln Laboratory, M.I.T. | July 1969 | U | AD 707577 |

Abstract: A high precision method for measuring the specular reflectivity of mirrors at 10.6$\mu$ with a $CO_2$ laser source when the reflectivity of the mirror approaches close to unity is described. The results of measurements on a range of evaporated thin film coatings are reported. Measurements at other wavelengths using a helium-neon laser have also been made, and this is discussed.

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| 70-84 | Linear Wave-Vector Shifts in the Raman Spectrum of $\alpha$-Quartz and Infrared Optical Activity | Lincoln Laboratory, M.I.T. | July 1969 | U | AD 707581 |

Abstract: Fine structure has been observed in the low-temperature Raman spectrum of the 128-$cm^{-1}$ E mode in $\alpha$-quartz. This structure is a manifestation of an allowed linear dependence of the optical-phonon frequency on wave vector. Since Raman scattering probes a small but finite wave vector, it is possible to observe these frequency shifts using high-resolution thermal or simulated Raman spectroscopy. The linear splitting of the 128-$cm^{-1}$ E-mode doublet is $0.86 \pm 0.05 \times 10^5$ cm/sec as determined by backscattering with several laser wavelengths. Such linear wave-vector shifts lead to optical activity in the far infrared (IR)/ The theory of the strength and dispersion of infrared rotary power is developed in order to establish the connection between the two phenomena. The rotary power for the 128-$cm^{-1}$ resonance can be estimated from the measured linear shift, liftime, and IR oscillator strength. However, a direct IR rotation measurement would be hindered by the associated absorption.

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| 70-85 | Example of the Generalised-Function Validity of the Rayleigh Hypothesis | Lincoln Laboratory, M.I.T. | November 1969 | U | AD 707574 |

Abstract: The electromagnetic field scattered by a conducting circular cylinder is expressed as an outward-going wave expansion in an eccentrically placed polar-co-ordinate system. It is shown that the expansion is always valid on the cylinder surface in the generalised-function sense but not in the conventional-function sense.

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| 70-86 | Intensities of Spin-Wave Resonance Modes in Thin Films | Lincoln Laboratory, M.I.T. | August | U | AD 707568 |

Abstract: Accurate measurements of spin-wave resonance absorption peaks from 5 to 70 GHz show that the deviation from a $1/p^2$ falloff is a strong function of frequency. It is pointed out that any intensity model must incorporate such frequency dependence.

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| 70-87 | Electrically Active Point Defects in Cadmium Telluride | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 707569 |

Abstract: Hall coefficient and conductivity measurements were made on a single crystal of CdTe at temperatures up to 950°C while controlling the partial pressure of either cadmium or tellurium. Measurements made with a cadmium reservoir showed the material to be n-type due to the presence of a doubly ionized native donor, in agreement with the results of Whelan and Shaw. The apparent enthalpy of formation of the donor and its concentration along the cadmium-rich solids were obtained. Measurements made with a tellurium reservoir close to tellurium saturation are in disagreement with the usual model, which attributes formation of p-type material under these conditions to the presence of a native acceptor defect. The results are consistent with a hole concentration originating from an excess of acceptor impurities rather than from a native acceptor.

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| 70-88 | The Fabrication of Microsound Components | Lincoln Laboratory, M.I.T. | March 1969 | U | AD 707816 |

Abstract: This paper is concerned with the technology required to fabricate microsound components and devices. The emphasis is on the future and probable trends and advances in realizing submicron structures.

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| 70-89 | Pressure-Induced Pyrochlore to Perovskite Transformations in the $Sr_{1-x}Pb_xRuO_3$ System | Lincoln Laboratory, M.I.T. | January 1970 | U | AD 707582 |

Abstract: The oxygen-deficient pyrochlore $Pb_2Ru_2O_{7-x}$ transforms to an orthorhombic perovskite near 90 kbar and 1400°C. As x decreases in the system $Sr_{1-x}Pb_xRuO_3$, the pressure for perovskite formation decreases to one atmosphere for $x \approx 0.3$. A pressure-composition phase diagram at 1400°C is presented. The quenched high-pressure perovskite phases retransform very slowly at 450°C and very rapidly at 600°C.

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| 70-90 | Simple Estimates of Wake Velocity Parameters | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 705590 |

Abstract: A technique for using a sequence of two-pulse bursts for obtaining estimates of mean wake velocity and wake velocity width has been proposed by W. D. Rummler of Bell Telephone Laboratories. The derivation of this technique was based on heuristic reasoning. The present note derives the same estimates from the theory of maximum likelihood estimation.

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| 70-91 | Scanback Antenna Control for Re-entry Physics Program | Lincoln Laboratory, M.I.T. | July 1961 | U | AD 706868 |

Abstract: This report describes the scanback subsystem installed at the M.I.T. Arbuckle Neck Site. The machine is capable of storing 1500 points in range, azimuth and elevation, permitting the antenna to be repositioned along a previously traversed path.

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| 70-92 | Oscilloscope Cameras for Video Recording--Reentry Physics Program | Lincoln Laboratory, M.I.T. | March 1961 | U | AD 706928 |

Abstract: This report describes the video recording cameras being used at the M.I.T. Arbuckle Neck Site in connection with Re-Entry Physics Experiment.

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| 70-93 | Interference Suppression Performance of Several FM Receivers Using Feedforward | Lincoln Laboratory, M.I.T. | July 1961 | U | AD 706407 |

Abstract: The feedforward signal-cancellation technique is based on subtractively combining the outputs of limiters and linear amplifiers having a common input. Used in an FM receiver, feedforward provides an attractively simple and effective method for suppressing interference to an FM

signal from other co-channel or adjacent-channel signals which may be either weaker or stronger than the desired signal. The thesis explores theoretically and experimentally the potential performance and inherent limitations of practical FM receivers using feedforward. Design criteria are discussed for various interference conditions and the relative merits of several practical feedforward circuits are considered. A laboratory model FM receiver was built and tested with three different feedforward circuits, its performance being measured under a variety of interference conditions. Significant improvements in the stronger-signal capture performance of a medicore FM demodulator was demonstrated. Sinusoidal modulation was recovered from FM signals between 0.05 and 0.9 times the amplitude of an interfering signal on the same channel, distortion ranging generally between 8 per cent and 30 per cent for various interference conditions. Completely intelligible speech modulation was also recovered from the weaker of two co-channel FM signals. Numerous suggestions for further work are given.

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| 70-95 | Air Traffic Control Quarterly Technical Summary | Lincoln Laboratory, M.I.T. | May 1970 | U | AD 707137 |

Abstract: This is the first report in the Quarterly Technical Summary series covering the Air Traffic Control activities at Lincoln Laboratory. The previous work on ATC was included in the General Research Quarterly Technical Summary. Because the allowable effort on ATC is comparatively small, it has been focused on only one facet of the problem; namely, on the data acquisition and communication task. The new group has started to make significant progress in several study aspects of the problem and has also obtained experimental L-band multipath data from an experimental air-ground test system. When additional support is received, the program will be expanded to include over-all system design studies and the investigation of radar improvements and multilateration systems, both ground-and satellite-based.

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| 70-96 | General Research Quarterly Technical Summary | Lincoln Laboratory, M.I.T. | May 1970 | U | AD 708721 |

Abstract: This Quarterly Technical Summary covers the period from 1 February through 30 April 1970. It consolidates the reports of Division 2 (Data Systems), Division 5 (Optics), Division 7 (Engineering), and Division 8 (Solid State) on the General Research Program at Lincoln Laboratory.

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| 70-97 | Germanium Microwave Switching Transistor | Lincoln Laboratory, M.I.T.* | September 1963 | U | AD 706857 |

Abstract: The fundamental approach used in this work was to develop suitable three-stripe geometry (emitter in the center with two outside base stripes) thus reducing base resistance.

*in cooperation with Texas Instruments, Inc.

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| 70-98 | Incoherent Scatter Measurements of F-Region Density, Temperatures, and Vertical Velocity at Millstone Hill | Lincoln Laboratory, M.I.T. | February 1970 | U | AD 706863 |

Abstract: The Millstone Hill Thomson (incoherent) scatter radar system has been operated routinely since 1963 to perform a synoptic study of F-region electron densities, and electron and ion temperatures. This report describes system changes made in 1968 which considerably increased the accuracy of the measurements and allowed their extension to higher altitudes. These changes have also made it possible to measure the vertical velocity of the plasma over the altitude range 450 to 900 km to an accuracy on the order of 5 to 10 m/sec, depending upon altitude and time of day. Of even greater significance, complete machine reduction of the results is now possible so that considerable savings in time and effort have been secured in

analyzing the data. The new system permits all the radar data to be gathered in the digital computer in real-time, thereby eliminating the need for post real-time processing of magnetic-tape recordings of the signals. Furthermore, it is now possible to transmit the data to other workers in computer-usable form. This report describes the main functions of the computer program required to analyze the measurements, and lists the times of all measurements made with the new system prior to 1 January 1970. Examples of these results are presented and discussed.

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| 70-99 | Low-Noise Receivers for Transportable Systems | Lincoln Laboratory, M.I.T. | April 1966 | U | AD 706139 |

Abstract: This paper discusses the use of low-noise receivers in transportable satellite communications ground terminals. A brief description of the Lincoln Laboratory Space Communications Program will be presented first. This will be followed by a discussion of the design considerations associated with transportable ground terminals. Emphasis will be placed on the constraints associated with the antenna-receiver-cryogenics interfaces. The Lincoln Experimental Terminal (LET) will be described as an example of a transportable terminal employing refrigerated parametric amplifiers and the performance characteristics of the LET parametric amplifiers will be presented.

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| 70-100 | A Modern Systems Approach to Signal Design | Lincoln Laboratory, M.I.T. | August 1966 | U | AD 706144 |

Abstract: Modern systems theory can be characterized by the use of state variable concepts and optimization techniques such as Pontryagin's maximum principle (the minimum principle). This paper is intended to provide a feeling for why modern systems theory is a viable approach to many signal design problems of communication and radar systems. The basic ideas and available results are summarized; the details are left to the cited references. The discussion is restricted to the use of modern systems theory for a particular class of signal design problems, no attempt is made to survey the whole signal design field.

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| 70-101 | Normal Mode Impedances of a Coupled Pair of Microstrip Transmission Lines | Lincoln Laboratory, M.I.T. | May 1968 | U | AD 706146 |

Abstract: This paper describes a method devised to obtain an accurate solution of the quasi-static problem, including a rigorous treatment of the inhomogeneous dielectric medium, making efficient use of computer time and obtaining an accurate assessment of the effects of an approximations employed.

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| 70-102 | A Low-Cost Latching Ferrite Phaser Fabrication Technique | Lincoln Laboratory, M.I.T. | May 1969 | U | AD 707864 |

Abstract: The electrical characteristics of latching ferrite waveguide phasers have been fairly well established, and increased attention is currently directed towards fabrication simplicity to reduce cost. Construction techniques considered in this paper permit the use of loosely toleranced ceramic and metal parts without sacrificing electrical and thermal performance of the phaser. An integral consideration is the degree that the flux-drive technique allows the relaxation of mechanical and ferrite material parameter tolerances.

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| 70-103 | Experimental Comparison of Hartree-Fock and Slater Exchange Potentials in Aluminum from the Charge Density Point of View | Lincoln Laboratory, M.I.T. | January 1969 | U | AD 706145 |

Abstract: Measurements on an absolute scale of the first nine structure factors of Al have been performed. Excellent agreement with calculations using the Hartree-Fock exchange potential was found for all but the first two, where solid state effects are important.

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| 70-104 | The Reckoner and the Mediator: A Consumer-Oriented On-Line System | Lincoln Laboratory, M.I.T. | August 1968 | U | AD 707573 |

Abstract: The full value of remote-console, time-shared systems will not be realized until they become easily accessible to consumers outside the computing fraternity. The Reckoner and the Mediator described in this paper were designed primarily for use by such consumers. The Mediator exemplifies a system organization which will support a wide variety of consumer-oriented applications. The Reckoner is an example of such an application in the realm of on-line computation.

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| 70-105 | Isotope Shift and Hyperfine Structure of the Neutron-Deficient Thallium Isotopes | Lincoln Laboratory, M.I.T. | February 1968 | U | AD 707570 |

Abstract: The measurements of the isotope shift and hyperfine structure of the neutron-deficient thallium isotopes has been extended to isotopes 196m, 195, and 194 m. The isotope shifts are $\Delta$ (196m-205)=-288$\pm$4 mK, $\Delta$ (195-205)=-274$\pm$4 mK, A° and $\Delta$ (194m-205)=-346$\pm$4 mK in the 5350 A line. (1 mK=$10^{-3}$ $cm^{-1}$.) In the 3776 line, the shifts are $\Delta$ (196m-205)=-288$\pm$10 mK, $\Delta$ (195-205)=-249$\pm$4 mK, $\Delta$ (194m-205)=-348$\pm$10 mK. The derived dipole moment of thallium -195 is (1.55$\pm$0.04)$\mu_N$. The shifts in the thallium sequence are compared with the shifts in the mercury sequence.

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| 70-106 | Magnetic Anisotropy and Magnetostriction Constants of MgMn Ferrites at 300°K | Lincoln Laboratory, M.I.T. | July 1969 | U | AD 707583 |

Abstract: The purpose of this communication is to report the results of room temperature measurements of magnetic anisotropy ($K_1$ and $K_2$) and magnetostriction ($\lambda_{100}$ and $\lambda_{111}$) constants for single crystals of magnesium-manganese ferrites. The three samples involved in the study were flux grown and later prepared in the form of polished spheres of about 1 mm in diameter. Both the anisotropy and magnetostriction constants were measured by the resonance techniques described in the previously reported work on lithium ferrites.

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| 70-107 | Resonant Raman Scattering from LO Phonons in Polar Semiconductors | Lincoln Laboratory, M.I.T. | June 1969 | U | AD 707571 |

Abstract: Multiphonon Raman scattering from LO phonons has previously been observed in CdS in the case where the laser frequency lies near the energy gap. The combined effects of finite wave vector and resonant energy denominators are offered as the explanation for certain features of the scattering. These features include the unusual polarization properties of the single-phonon scattering and the unexpected sharpness of the two-phonon line. The effects of the Frohlich interaction are calculated in lowest-order perturbation theory under the assumption of spherical, parabolic bands. The important part of the scattering amplitude is due to terms where the laser is resonant to interband transitions. Since the parameter $qv/w_L$ is of order unity, the dipole approximation $q \rightarrow 0$ is not applicable. (Here v is the electron velocity at that point in the zone where the laser can cause real transitions.) In the single-phonon scattering q is the difference between the wave vectors of the incident and scattered photons, while for the double-phonon case, q is the wave vector of one of the two final-state phonons. No exciton effects are included. The temperature is taken to be zero throughout.

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| 70-108 | Ionized Impurity Density in n-Type GaAs | Lincoln Laboratory, M.I.T. | July 1969 | U | AD 707572 |

Abstract: Total ionized impurity densities ($N_D + N_A$) from $7 \times 10^{13}$ to $3 \times 10^{17}$ $cm^{-3}$ are determined for epitaxial samples of n-type GaAs by analyzing mobility and carrier concentration data as a function of temperature with the Brooks-Herring formula for ionized impurity scattering. The procedure results in the determination of a temperature range within which the effects of other scattering mechanisms are minimal and gives values of $N_D$ and $N_A$ which are in good agreement with impurity densities obtained from analyses of the temperature variation of the Hall constant. These results are then used to determine empirical curves relating the impurity density to the 77°K Hall mobility. With these data a good estimate of the total ionized impurity concentration in a sample can be determined from Hall constant and resistivity measurements at 77°K.

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| 70-109 | Reinterpretation of $^4A_2 \rightarrow {}^2E$ Exciton Spectra in $YCrO_3$ | Lincoln Laboratory, M.I.T. | September 1969 | U | AD 707566 |

Abstract: The results of a detailed group theory analysis of the $^4A_2 \rightarrow {}^2E$ excitons in $YCrO_3$ are presented and the data of Aoyagi, Tsushima and Sugano is reinterpreted using these results.

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| 70-110 | High Temperature Electrical Properties of CdSe: Evidence for a Native Donor | Lincoln Laboratory, M.I.T. | October 1969 | U | AD 707495 |

Abstract: Hall coefficient and conductivity measurements have been made on cadmium selenide single crystals, in cadmium atmosphere, at temperatures up to 950°C. The crystals are n-type, and the electron concentration increases with the +1/3 power of the cadmium pressure. This behavior indicates the presence of a native donor, probably either a cadmium interstital or selenium vacancy, which is doubly ionized at temperatures above 600°C. The enthalphy of formation of this donor and its concentration along the cadmium-rich solids have been determined.

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| 70-111 | Three Axis Attitude Control of a Synchronous Communications Satellite | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 707472 |

Abstract: LES-7 will be a synchronous communications satellite with automatic stationkeeping and three axis attitude control capabilities. On the earth oriented face of the satellite body will be a 30-inch diameter X-band (8 GHz) lens antenna. A 500 watt solar plant, consisting of two flat panels, each about 5 feet square, will be deployed on shafts from the north and south faces of the satellite body and oriented toward the sun so that relative to the panels, the body will rotate once per orbit.

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| 70-112 | The Future of Self-Contained Control of Synchronous Orbits | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 707489 |

Abstract: Stationkeeping of satellites can be accomplished by command from the ground, self-contained methods, or a combination of both. These techniques are compared when applied to networks of synchronous satellites. Self-contained control requires less frequent tracking and orbit determinations. This is important because future systems will need stationkeeping accuracies of 0.1° of longitude or better, for increasingly numerous satellites. The first automatic stationkeeping system, launched on LES-6 in 1968 has achieved control within ± 2° and is providing data on long-term sensor behavior. Weight and power penalties for the self-contained feature were 4 lb and 0.120 W. The LES-7 control system is being designed for control to ± 0.25°, with 4 lb and 4 W penalties. Future self-contained systems will obtain 0.1° accuracy with little additional complexity. Ground stations would monitor and intervene by command in emergencies.

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| 70-113 | Variable-Coverage Communications Antenna for LES-7 | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 707477 |

Abstract: LES-7 will be a geostationary, 3-axis stabilized satellite with a variable-coverage, X-band communications antenna system on board. An experimental model of this system, consisting of a wavelength lens, a 19-horn feed cluster and a combiner switch, exhibits coverage varying from that of a 3° pencil beam to a full-earth hemisphere. The double-concave waveguide lens has a 30-inch diameter, an F/D ratio of unity, and is stepped on one side to reduce weight and to increase bandwidth. The feed cluster is an hexagonal array of conical horns having 2-inch apertures and spaced 2 inches apart. The antenna bandwidth corresponding to a 1-dB loss of gain is about 15 percent. The earth-coverage pattern shows a peak-to-peak ripple of 2 dB and an average gain of 21.5 dB. A computer study of this antenna yielded results in good agreement with measurements.

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| 70-114 | The TATS Master - A Net Controller for Tactical Satellite Communications | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 707479 |

Abstract: Most military and civilian tactical communication traffic is organized in net structures following chains of command. In the case of tactical communication satellites the bandwidth available is limited, resulting in satellite capacity being limited. In satellite nets, therefore, it is imperative to implement well designed automatic net control procedures which can insure both efficient satellite use and ready availability of reliable communications. The TATS Master is an automatic net control station for operating a satellite communications net consisting of many terminals with TATS modems operating at UHF at a data rate of 75 bits/sec. TATS (Tactical Transmission System) is a frequency-hopping modulation system for tactical satellite communications which has been designed to provide a high degree of random multiple-access capability, RFI resistance, and protection against multipath. Most net member stations will be located on aircraft, ships, or small land vehicles. All net member stations are provided with a small add-on box to provide automatic response capability. The TATS Master physically consists of several TATS modems connected to a small general purpose digital computer with a number of input/output devices. With such a terminal, a commander or controller can maintain semiautomatic control over large numbers of terminals which comprise his communications network.

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| 70-115 | Visible Light Sensors for Circular, Near-Equatorial Orbits | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 707473 |

Abstract: For specified orbital conditions and accuracies in the region of $1.0^{\circ}$ to $0.1^{\circ}$, visible detectors are capable of supplying the needed information for satellite control systems and antenna pointing. Within the restrictions set forth in this paper and with the knowledge of the relatively simple sensor and system designs needed, visible detectors have a decided advantage over IR sensors. To date, 65 visible radiation sensors (30 earth and 35 sun sensors) have been flown. None of the 318 sensing diodes contained in these sensors have malfunctioned.

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| 70-116 | A Non-Sliding Rotary Electrical Connector | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 707474 |

Abstract: This paper describes a new type of rotary electrical contact which virtually eliminates conventional wear problems because it has no sliding surfaces. Through the use of a seldom used principle of motion, intimate physical contact between rotating and stationary bodies is achieved through large apparent contact areas with no sliding. The design of a prototype device is described in detail as well as test data vertifying the efficient performance of a variety of contact sizes. The prototype device included a speed reducer and drive motor so that the whole assembly could support, drive and conduct current and signals from a satellite solar panel. Test data included shows that it may be possible to achieve electrical connections across this common rotary interface in space vacuum that are as efficient as bolted connections and have no sliding wear problems, as do existing devices.

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| 70-117 | Lincoln Experimental Satellites 5 and 6 | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 707475 |

Abstract: The paper describes the satellites and their use both as part of a demonstration of the feasibility of satellite communications at VHF/UHF to small mobile terminals and as test beds for experimental subsystems of interest to spacecraft designers. Both spacecraft employed highly efficient solid-state RF sources and circularly polarized antennas. The LES-6 antenna was electronically despun to realize about 8.5 db gain. Experiments emphasized autonomous satellite operations in stationkeeping and attitude control. The stationkeeping thrust was provided by a novel pulsed plasma thruster. Other experiments measured uplink RF interference in the band from 255 to 315 MHz, localized earth albedo in the visible spectrum, and the effects of the synchronous orbit environment on solar cells. The on-orbit performance of the satellites and the experimental subsystems are included.

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| 70-118 | Evaluation of Techniques for Estimating Titan III-C Flight Loads | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 707480 |

Abstract: Before an actual payload configuration is known, the boost phase inertia loads on the payload must be estimated in order to be useful in the design of a satellite. Two techniques for predicting these loads are evaluated. The first is a straightforward application of Fourier transforms. The input data are known spectra of the booster/payload interface accelerations and forecast payload transfer functions. These transfer functions are based on anticipated payload dimensions, mass distribution, and important modes, frequencies and damping. Application to a multi degree-of-freedom system is demonstrated. The second approach models the interface accelerations as a super-positioning of a finite number of enveloped narrow band excitations whose center frequencies lie at the lower natural frequencies of the booster. The envelope functions are chosen to reflect the transient, non-stationary character of the excitation. Assuming the envelope to be "slowly varying," the task of obtaining the mean square model response of the satellite is shown to be relatively simple.

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| 70-119 | Preliminary Results from the LES-6 Solar Cell Experiment | Lincoln Laboratory, M.I.T. | April 1970 | U | AD 707483 |

Abstract: In order to study solar cell degradation in synchronous orbit, a solar cell experiment was flown on the Lincoln Laboratory LES-6 satellite. The experiment consists of thirty cells of various types. Preliminary results have been obtained from the first year of observation. Maximum power degradations range from 10 percent for a cell comparable to that in a properly constructed solar array to 35 percent for a cell which experiences low energy proton damage. Lithium doped p/n cells faired poorly, degradation as high as 42 percent being noted in one unit.

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| 70-122 | Microprogramming Project - Year End Report | MITRE Corporation, Bedford, Mass. | May 1970 | U | AD 704891 |

Abstract: This document summarizes the activities of Project 7120, $C^3$ Computer System Organization, for Fiscal Year 1969. The project objectives included experimentation with microprogramming on an Interdata 3 computer installed at The MITRE Corporation.

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| 70-123 | The Effect of Meteorological Conditions on the Trade Wind Duct and Related Radio Wave Propagation | Syracuse University Research Corporation | February 1970 | U | AD 706132 |

Abstract: The horizontal extent and the intensity of the Trade Wind Inversion are controlled by meteorological conditions. The subtropical area of the Caribbean is influenced by subsiding air which tends to produce a temperature inversion around one kilometer above the sea surface. The vertical transport of water vapor is thereby inhibited and a boundary forms along the inversion with moist air below and dry air above. The index of radio refraction therefore decreases rapidly with height through this layer to form an elevated duct. The meteorological situation controlling the characteristics of this duct varies from the normal high pressure condition. Interest is therefore centered on the variability of the inverstion layer as affected by weather systems and local geographical conditions.

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| 70-124, Vol. I | GRASP: A PL/I Compatible Graphics Subroutine Package for the IBM 2260 Display Station (Local Attachment) Vol. I - Introduction and User's Manual | MITRE Corporation, Bedford, Mass. | May 1970 | U | AD 706133 |

Abstract: GRASP is a set of PL/I compatible subroutines which provide programming support for the IBM

2260 Display Station in local attachment; i.e., the attachment of a 2260 directly to a System/360 CPU channel via the IBM 2848 Display Control. The subroutines are coded in OS/360 Assembler Language and are reentrant. They permit the PL/I programmer to manipulate the 2260 as an I/O device in the same manner available to the Assembler Language programmer using the Graphics Access Method under OS/360 (with restrictions as noted in the Introduction to Volume I of this document). All errors, except those which normally result in OS/360 abnormal ends (ABENDS), are returned to the user via subroutine parameters. GRASP is designed to operate under the MFT configuration of OS/360. Volume I of this document gives an overview of the 2260 and an introduction to the GRASP routines. Volume II gives detailed program specifications.

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| 70-124, Vol. II | GRASP: A PL/I Compatible Graphics Subroutine Package for the IBM 2260 Display Station (Local Attachment) Vol. II - Program Specifications | MITRE Corporation, Bedford, Mass. | May 1970 | U | AD 706134 |

Abstract: GRASP is a set of PL/I compatible subroutines which provide programming support for the IBM 2260 Display Station in local attachment; i.e., the attachment of a 2260 directly to a System/360 CPU channel via the IBM 2848 Display Control. The subroutines are coded in OS/360 Assembler Language and are reentrant. They permit the PL/I programmer to manipulate the 2260 as an I/O device in the same manner available to the Assembler Language programmer using the Graphics Access Method under OS/360 (with restrictions as noted in the Introduction to Volume I of this document). All errors, except those which normally result in OS/360 abnormal ends (ABENDS), are returned to the user via subroutine parameters. GRASP is designed to operate under the MFT configuration of OS/360. Volume I of this document gives an overview of the 2260 and an introduction to the GRASP routines. Volume II gives detailed program specifications.

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| 70-130 | Interference Prediction Guidelines for VHF Non-Tactical Fm Communications | Electromagnetic Compatibility Analysis Center | May 1970 | U | AD 707492 |

Abstract: This technical report presents guidelines which may be used for the prediction of interference effects between collocated VHF non-tactical FM equipments. Pertinent technical characteristics and interference susceptibility levels representative of this type of equipment are included. The interference mechanisms discussed include cochannel and adjacent channel effects and non-linear interactions due to spurious receiver responses, and transmitter and receiver intermodulation interference. Sample problems are set forth and solved to illustrate the step by step procedure for prediction of each type of interference phenomenon considered, and the equipment modifications required to prevent degradation.

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| 70-134 | Compatibility Factors Affecting Concept Development of Approach and Landing Guidance System | Electromagnetic Compatibility Analysis Center | May 1970 | U | AD 707129 |

Abstract: Results presented in this report issue from four tasks undertaken for the FAA. These results contribute to the specification of a concept for a guidance system for approach and landing. The electromagnetic emitter environment is established for the 1975 time frame for the frequency bands, 5.0 to 5.25 GHz, 9.0 to 9.2 GHz, and 15.4 to 15.7 GHz. Possible interactions between a proposed guidance system located at John F. Kennedy International Airport and the 9.0 to 9.2 GHz band emitter/receiver environment are established. Estimates are made of the minimum number of separate channels required of a guidance system. Channel frequency separation requirements for a specific signal format/system deployment are also established.

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| 70-141 | The Design and Implementation of a Conversational Extensible Language | Harvard University | May 1970 | U | AD 709361 |

Abstract: This report describes CEI, a conversational extensible language. Its syntax, data, control structures and conversational features are presented and compared to those of other languages. Its use is illustrated by means of several examples in the areas of list processing, polynominal arithmetic, formula manipulation, vector arithmetic, trees and syntax analysis, complex and rational arithmetic and block strucutre and own variables.

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| 70-148 | Solid State Research | Lincoln Laboratory, M.I.T. | May 1970 | U | AD 711074 |

Abstract: This report covers in detail the solid state research work of the Solid State Division at Lincoln Laboratory for the period 1 February through 30 April 1970. The topics covered are Solid State Device Research, Materials Research, Physics of Solids, and Microelectronics. The microsound work is sponsored by ABMDA and is reported under that program.

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| 70-149 | Signal Processing Results for Continental Aperture Seismic Array | Lincoln Laboratory, M.I.T. | May 1970 | U | AD 707863 |

Abstract: The processing of short-period P-wave data from a continental aperture seismic array is considered. The array consists of sites located at the Large Aperture Seismic Array (LASA) in eastern Montana and Long Range Seismic Measurement (LRSM) stations located in North America. In particular, the feasibility of recognizing the arrival of the P phase, making use of P-pP differences in velocity across such a large array, is considered. In addition, the determination of the P-wave source structure of an event is considered by using the array to essentially steer many beams in the vicinity of the epicenter of the event. The capability of the array to perform these two functions is evaluated and discussed in detail.

70-150 | Magnetic Moment Versus Temperature Curves of Ferrimagnetic Garnet Materials | Lincoln Laboratory, M.I.T. | September 1970 | U | AD 715284

Abstract: The molecular field coefficients employed in the Néel theory of ferrimagnetism have been determined as functions of the levels of diamagnetic ion substitution in the garnet family $\{Y_zGd_{3-z}\}$ $[R_xFe_{2-x}]$ $(Q_yFe_{3-y})$ $O_{12}$, where R and Q represent diamagnetic octahedral and tetrahedral substitions, respectively. The coefficients may be listed as:

$N_{dd} = -30.4\ (1-0.43x)$
$N_{aa} = -65.0(1-0.42_y)$
$N_{cc} = 0$
$N_{ad} = 97.0(1-0.125x-0.127_y)$
$N_{cd} = 6.0$
$N_{ac} = -3.44$ moles/cm$^3$

With these coefficients the magnetic moment versus temperature curve of compositions ranging from $0 \leq x \leq 0.70$, $0 \leq y \leq 1.95$, and $0.40 \leq z \leq 1.00$ were computed and are presented in this report.

70-151 | Graphics, Semiannual Technical Summary Report to the Advanced Research Projects Agency | Lincoln Laboratory, M.I.T. | May 1970 | U | AD 709187

Abstract: Software design for the Terminal Support Processor (TSP) system has concentrated on the specification of a language called LIL (for Local Interaction Language). Designed for interpretation by a micro-processor in the TSP system, LIL is a general purpose language with primitives for manipulating display structures and handling message-oriented input-output. The user specifications for LIL are now available and are presented here in considerable detail. A new mechanism for triggering a user program at interrupt level has been implemented on TX-2. The mechanism uses signals derived from hardware devices which can monitor the state of TX-2 control registers. An experimental interactive program

has been written to illustrate one application area for the new facility: software measurement. A new character generator has been installed on TX-2. The storage scope editor on TX-2 has been refined and extended on the basis of user experience. Cursor visibility has been improved by flashing the cursor at a rate of six per second. The Basic Combined Programming Language (BCPL) compiler on TX-2 has been optimized. An overall compilation speed improvement of 374 percent has been achieved in part by making use of the new performance measurement tools now available. An on-line documentation system has been developed for preparing, editing, and presenting system documentation on a variety of output devices. On-line documentation is now available for many parts of the TX-2 system.

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| 70-154 | Education Technology Program | Lincoln Laboratory, M.I.T. | June 1970 | U | AD 709188 |

Abstract: A program in Educational Technology was initiated by the Laboratory in November 1969. It was first reported in the 15 February 1970 General Research Quarterly Technical Summary. Background material from that report is included here so that the present series of reports will be complete and self-contained.

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| 70-155 | Rain Attenuation at Millimeter Wavelengths | Lincoln Laboratory, M.I.T. | March 1968 | U | AD 707813 |

Abstract: The major propagation problem confronting the use o[illegible]ves for line-of-sight communication links operating through the atmosphe[illegible]our scattering. Rain, hail, sleet, snow, and fog all can cause severe attenu[illegible]limeter wave frequencies. The problems of hydrometeor scattering have been recognized for years and recent measurements reported in the literature tend to support the conclusions that the current theory is not sufficient to adequately predict attenuation.

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| 70-156 | Computer Assistance in the Layout of Integrated Circuit Masks | Lincoln Laboratory, M.I.T. | March 1968 | U | AD 707817 |

Abstract: As integrated circuit technology progresses, it becomes increasingly important to use a computer to assist in the tedious and time-consuming task of mask layout. To this end, an on-line graphics program for integrated circuit mask layout has been developed for the M.I.T. Lincoln Laboratory TX-2 computer.

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| 70-157 | Experiments with a $CO_2$ Laser Radar System | Lincoln Laboratory, M.I.T. | August 1968 | U | AD 707810 |

Abstract: Radar techniques can be used for determining several characteristics of remote objects, the principal ones being range, velocity, and reflection cross-section. Advances in laser technology now allow some of these techniques to be extended into previously inaccessable high frequency ranges, corresponding to infra-red and optical wavelength regions. Shorter wavelengths, in principle, permit increased precision spatial measurements as well as narrowing of transmitted beams. The program described here is concerned with velocity determinations through measurement of the Doppler frequency shifts and character of reflections from moving bodies.

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| 70-158 | A 48 Inch Telescope/ Spectrograph for Reentry Measurements | Lincoln Laboratory, M.I.T. | August 1968 | U | AD 707811 |

Abstract: This paper describes the characteristics of a 48 inch telescope/spectrograph located on Kwajalein, M.I., its operation in the field, its mode of tracking and method of radiometric calibration. Data showing the high spatial and spectral resolution obtainable will be presented.

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| 70-159 | Optical Measurements and Information on the PRESS KC-135 Aircraft | Lincoln Laboratory, M.I.T. | August 1968 | U | AD 707812 |

Abstract: A KC-135 aircraft has been instrumented for the measurement of radiation emitted by the members of a missile family as they re-enter the atmosphere. The instruments, the mounts, and the automatic control system are described in terms of the design goals and of the achieved performance. A short description of the calibration equipment and methodology is presented. The limitations and uncertainties of radiation measurement and resolution photography have been estimated and are discussed briefly.

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| 70-160 | The Use of Image Intensifiers in Radiometric Measurements | Lincoln Laboratory, M.I.T. | August 1968 | U | AD 708596 |

Abstract: The 48-inch telescope at Kwajalein is presently being used to gather information on spectral signatures of missile re-entries. The sensitivity of this spectrometer is determined by the threshold sensitivity of the film used. The aimof our effort is to extend the overall system sensitivity in obtaining re-entry data at an earlier point than is now possible, and to improve the resolution of the spectral date (in those cases where it is sensitivity limited).

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| 70-161 | Radio Meteorological Applications of Automatic Film Reading | Lincoln Laboratory, M.I.T. | August 1968 | U | AD 708593 |

Abstract: Relatively simple applications of automatic reading can be of great value in some of the data reduction problems encountered. Though neither of two applications described in this paper is yet completely operational, both are workable examples, and simple extensions or modifications of the concepts presented can be of value in the automatic processing of similar data in other fields.

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| 70-162 | Solar Cell Degradation Experiments on LES-4 and -5 | Lincoln Laboratory, M.I.T. | November 1968 | U | AD 708603 |

Abstract: Lincoln Laboratory satellites LES-4 and -5 each carry solar cell experiments:

$V_{oc}$ measurement of 10 ohm cm silicon cell with 30-mil cover slide
$I_{sc}$ measurement of 10 ohm cm silicon cell with 30-mil cover slide
$I_{sc}$ measurement of 10 ohm cm silicon cell with 6-mil cover slide
$I_{sc}$ measurement of two CdTe thin film cells (LES-4 only)
$I_{sc}$ measurement of two CdS thin film cells (LES-5 only)

LES-4 was orbited in December 1965 in a highly elliptical oribt with an 18,000-mile apogee and a 100-mile perigee; LES-5 was injected into quasi-synchronous orbit in July 1967. In the LES-4 experiment, the Si cell with 6-mil cover slide shows two rates of degradation with the break point occurring at bout 100 days; the cell with the 30-mil cover slide shows substantially less degradation. After 700 days, the short circuit currents ($I_{sc}$) of these two cells are 60 and 78 percent of their initial air mass zero (AMO) values. One CdTe cell decayed to 38 percent of its initial AMO value after 700 days; the second sample gives anomalous results. In the LES-5 experiment, the Si cell exhibit an $I_{sc}$ degradation of eight percent per year plus an initial short term degradation of four percent; open circuit voltage ($V_{oc}$) is relatively unaffected. The CdS cells have an $I_{sc}$ degradation of 20 percent per year plus an initial degradation of five percent. In each experiment AMO to AMI short-circuit current ratios of approximately 1.09 were noted.

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| 70-163 | Solar Cell Calibration Experiments on LES-6 | Lincoln Laboratory, M.I.T. | November 1968 | U | AD 708598 |

Abstract: The sixth Lincoln Laboratory Experiment Satellite (LES-6) was placed in a synchronous orbit on 26 September 1968. Among instrumentation on board is a solar cell calibration experiment

to measure the V-I characteristics at various angles of solar incidence of 30 solar cells including standard n/p (silicon (Si) cells with 6-mil cover slides, Si n/p) cells with 1-mil sputtered silica coverings, p/n lithium drifted cells with integral covers, dendritic n/p cells with a 6-mil cover slides and with 2-mil integral covers, ion implant Si cells with 1-mil integral covers, CdS thin film cells and CdTe thin film cells. Calibration of the experimental cells was carried out at Kitt's Peak near Tucson, Arizona. Initial orbital results have agreed closely with those expected from the calibration.

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| 70-164 | Band-Pass Time-Domain Reflectometry | Lincoln Laboratory, M.I.T. | March 1969 | U | AD 708601 |

Abstract: It is often desirable to apply the techniques of time-domain reflectometry to the measurements of waveguide circuits and other components such as circulators, amplifiers, antennas, etc., which cannot pass the usualy pulses used in baseband reflectometry. Techniques for the generation of well-controlled microwave pulses with desired bandwidth characteristics and sidelobe levels less than -40 dB are described. A comparison is made between results obtained using the short pulse TDR methods and results from conventional phase and amplitude measurements.

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| 70-165 | Photographic Film as a Radiometric Imaging Detector | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 708599 |

Abstract: Conventional photographic films find wide application in radiometric image measurements, both as a prime detector and as an output recording medium. The most significant properties of films for these applications are identified and the peculiarities as well as the traditional advantages of film are discussed.

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| 70-166 | Application of the Optical Transfer Function in Electro-Optical Systems | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 708602 |

Abstract: The role of the optical transfer function in designing and optimizing the overall performance of complex electro-optical systems will be discussed. The question arises in systems incorporating image tubes together with their associated optics, whether the best possible image is being obtained. Furthermore, how should the different components be adjusted for the highest overall performance of the system? In this context, the advantages in the use of the optical transfer function over the still more usually specified limiting resolution characteristics in image evaluation analysis will be examined. The main factors and limitations that influence the inherent optical performance will be considered with regard to specific systems. Direct experimental measurement of the effective contrast transfer characteristics of image tubes independently of any lens systems by means of a simple optical technique will be proposed.

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| 70-167 | Radar-Mapping of Venus with Interferometric Resolution of the Range-Doppler Ambiguity | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 709749 |

Abstract: A map of the surface reflectivity of Venus at a wavelength of 3.8 cm is obtained by using a fixed base line radar interferometer. The two-fold hemispheric ambiguity in the range-Doppler map has been resolved by interferometry. The map covers a region extending approximately from -80° to 0° longitude (Carpenter's Definition) and from -50° to 40° in latitude. The map shows many new features in addition to delineating clearly features already observed. Large circular regions with a radar appearance similar to lunar maria are among the newly observed features. Analysis of the method employed in resolving the hemispheric ambiguity shows that the relatively small range of projected base line change available produces only small sidelobes in the noise level.

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| 70-168 | Specific Heat of EuO | Lincoln Laboratory, M.I.T. | November 1969 | U | AD 709744 |

Abstract: We report measurements of the specific heat C of two single crystals of EuO over the range of temperatures from 0.37° to 4.4°K and in the presence of external magnetic fields up to 13 kOe. The results for these two samples, which were grown from different batches, are consistent within a few percent. The primary contribution to C above 0.7°K is described in terms of spin-wave theory. From an analysis of the data we find $J_1/k_B = (0.76 \pm 0.02)$°K and $J_2/J_1 = -0.11 \pm 0.02$ in excellent agreement with another determination. Below 0.7°K, the dominant contribution to C arises from the hyperfine splitting of the $^{151}Eu$ and $^{153}Eu$ nuclear levels. The magnitude of this contribution corresponds to an effective hyperfine field $H_N = 300 \pm 5$ kOe in agreement with the value deduced from NMR and Mössbauer experiments.

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| 70-169 | Avalanche Breakdown and Light Emission at Low-angle Boundaries in n-ZnSe | Lincoln Laboratory, M.I.T. | May 1969 | U | AD 708604 |

Abstract: Low angle boundaries in n-ZnSe can behave as back to back diodes. This behavior is similar to that observed at low angle grain boundaries in n-Si and Ge. In ZnSe, breakdown occurs when the low angle boundary is biased to approximately 20 V in either direction. This breakdown is accompanied by broad visible electroluminescence.

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| 70-170 | Magnetoemission Experiments in $Pb_{1-x}Sn_xTe$ | Lincoln Laboratory, M.I.T. | April 1969 | U | AD 708597 |

Abstract: Reduced effective masses and g-factor magnitudes in $Pb_{1-x}Sn_xTe$ ($0 \leq x \leq 0.27$) are deduced from the dependence of the emission spectra on <100> magnetic fields. Their band gap dependence is as expected if valence-conduction band interaction provides the primary contribution, with higher and lower lying bands having a lesser, but significant, effect.

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| 70-171 | RFI Measurements at UHF on a Pulsed Plasma Thruster | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 708591 |

Abstract: Experimental Pulsed Plasma Thrusters (PPT) were flown aboard the Lincoln Experimental Satellite LES-6 to provide the thrust necessary for a stationkeeping experiment. The thrusters were manufactured by Fairchild-Hiller Republic Division, and provided an approximate 6$\mu$ lb-sec impulse from each dischange of 1.85 joules of electrical energy. A Radio-frequency interference (RFI) specification was drawn up along with a measurement procedure. The RFI specification, measurement procedure, and measured results are the subjects of this Note.

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| 70-172 | Inelastic Light Scattering from Semiconductor Plasmas in a Magnetic Field | Lincoln Laboratory, M.I.T. | September 1969 | U | AD 708590 |

Abstract: The cross section for the inelastic scattering of light from mobile carriers in semiconductors immersed in a dc magnetic field $B_o$ is calculated approximately in a manner sufficiently general to include directly particle-particle Coulomb interactions (in the random-phase approximation) and energy-band structure of an arbitrary nature. The effect of Coulomb interactions on the momentum matrix elements occurring in the calculation is neglected, but is kept in the evaluation of the correlation function of a generalized electron-pair operator. The results encompass scattering from the various longitudinal magnetoplasma collective modes, and single-particle excitations between Landau levels and spin states. Resonant enhancement factors are automatically included, as are spin-orbit-induced effects such as scattering from spin-density fluctuations and spin waves. Low-temperature electrons in semiconductors of the indium antimonide type are used as a specific example to illustrate general features of the scattering for the two major geometries: $q \perp B_o$ and $q \parallel B_o$, where q is the scattering wave vector. For $q \perp B_o$, inter-Landau-level scattering is shown to suffer significant screening due to Coulomb interactions. Also, in this geometry it is shown that the strength of the scattering from the Bernstein modes is of the order of the strength for the associated inter-Landau-level excitation, contrary to the conclusions of previous authors.

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| 70-173 | Surface-Height Variations on Venus and Mercury | Lincoln Laboratory, M.I.T. | December 1969 | U | AD 709750 |

Abstract: Radar time-delay and Doppler observations have been used to infer surface-height variations near the equator of Venus. One method, applicable along the apparent equator within a few degrees from the subradar point, has a resolution of about 25 km in longitude and 200 km in latitude and has disclosed an elevated region with a height of about 2 km. Within the latitudinal-resolution cell, the region extends 150 km in longitude and has a radar cross section enhanced by about 4 db above average. A second method employs measurements of the round-trip delay to the subradar point on the target planet. These data, accumulated over a number of years, cover the entire equatorial region on Venus, although nonuniformly. Each observation has a resolution along the surface of about 1000 km. Comparison of the measured values with predictions that assume Venus to be spherically symmetric, but that take into account all other significant effects, shows systematic trends in the residuals as a function of the longitude on Venus of the subradar point. A model in which the equator is assumed to be elliptical (semi-major axis, a; semi-minor axis, b) with center offset by $\Delta\rho$ from the center of mass allows the systematic trends to be removed. With all relevant parameters estimated simultaneously, we find $\Delta p = 1.5 \pm 0.3$ km and $a - b = 1.1 \pm 0.4$ km (formal standard errors). Typically, the actual uncertainty is several times the formal error. The direction (of $\Delta p$, ) determined with a formal standard error of $10^{\circ}$, points approximately away from the earth at inferior conjunction. The first method has not been applied to Mercury because of its weaker echo signal. The second method, using data that cover the entire equatorial region, yields time-delay residuals which show no systematic trend when displayed as a function of the longitude on Mercury of the subradar point; the estimates for $\Delta p$ and $a - b$ are both less than their respective formal standard errors of 0.4 and 0.2 km. Thus, both Venus and Mercury possess surface height variations far smaller in magnitude than those of either the earth or Mars.

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| 70-174 | A Stable Frequency Doubler Using a Series-Parallel Array of Eight Diodes | Lincoln Laboratory, M.I.T. | October 1969 | U | AD 709754 |

Abstract: Experimental results of a doubler (output frequency 1.8 GHz) using a series-parallel array of eight punch-through diodes is presented. Techniques used to prevent spurious oscillations are described.

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| 70-175 | Remote Probing of the Moon by Infrared and Microwave Emissions and by Radar | Lincoln Laboratory, M.I.T. | September 1969 | U | AD 709760 |

Abstract: The results of the remote probing of the moon by means of infrared and microwave emissions and by radar are reviewed. Also, we discuss how the various observational results can help to explain physical parameters of the lunar surface, such as thermal and electrical conductivities, dielectric constant, density, particle sizes in the lunar regolith, depth of the surface layer, roughness of the surface, variation of these parameters from point to point on the surface, and amount of heat generated in the lunar interior.

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| 70-176 | Resonant Amplification and Coupling of Acoustic Surface Waves with Electrons Drifting Across a Magnetic Field | Lincoln Laboratory, M.I.T. | February 1970 | U | AD 708592 |

Abstract: We show that acoustic surface waves on a piezoelectric can be resonantly amplified by coupling to a weakly damped carrier surface wave on an adjacent semiconductor in which the conduction electrons are made to drift across an applied magnetic field. The conditions for such a wave-wave interactions are established, and calculations of the growth rate and its characteristics are given. Under the same conditions, reversing the direction of the magnetic field changes the amplifier to an almost loss-free, tunable, coupler.

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| 70-177 | A Theory of Multiple Modes in Avalanche Diodes | Lincoln Laboratory, M.I.T. | June 1970 | U | AD 711923 |

Abstract: This report develops a multidimensional, dynamic analysis of solid state avalanche diodes. Well-established electromagnetic concepts are applied to a widely used model of the diode and reveal a discrete spectrum of new small-signal modes. The approach used enlarges the conventional perspective and has permitted the discovery that at least one of these new modes appears to possess a high power capability (associated with its two-terminal negative resistance) which has been partially realized experimentally. The lowest-order mode contains all the results of prior quasi-static theories on the normal IMPATT mode, plus additional information which is used to delineate the range of validity of the quasi-static results. Formal discrepancies are uncovered between the usual quasi-static, one-dimensional result for diode impedance used in solid state studies and the dynamic multidimensional result for the normal IMPATT mode developed from microwave circuit theory. However, these discrepancies are numerically quite small except in certain narrow frequency bands.

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| 70-180 | Design of Stable, High Efficiency, High Power Upper Sideband Upconverters | Lincoln Laboratory, | June 1970 | U | AD 709362 |

Abstract: This report presents a logical design procedure to build stable, efficient varacter upper sideband upconverters. It establishes general design criteria to provide (1) unconditional stability, (2) low spurious, (3) predictable diode impedance levels, and (4) predictable efficiency. A sample design is included to illustrate one means of realizing the design constraints and showing the agreement between predicted and achieved stability, impedance match, efficiency, and power output. The second part of the report discusses means of obtaining high power operation by using multiple varactors. It is concluded that the best configuration is a series stack of varactor diodes. With allowance made for the package parasitic reactances, it is proven analytically that stacked, packaged diodes operate efficiently as an upper sideband upconverter. Finally, an example of a stacked varactor upconverter design was built and measured. The agreement between predicted and obtained results is remarkably good.

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| 70-182 | Two-Magnon Raman Scattering in $KNiF_3$ | Lincoln Laboratory, M.I.T. | November 1969 | U | AD 709747 |

Abstract: Raman scattering of 5145-Å argon laser radiation by two magnons in the perovskite antiferromagnet $KNiF_3$ has been observed. At low temperature, the spectrum of the scattered light is in excellent agreement with a Green's function theory for a perovskite with S=1 and nearest-neighbor exchange constant $J = (71.0 \pm 0.8)\ cm^{-1}$. If the effects of anisotropy (obtained from far-infrared antiferromagnetic resonance measurements) are included, the value of J is changed only slightly, decreasing $\approx 0.5\ cm^{-1}$. The line shape and position were also observed as functions of temperature. A comparison is made with similar scattering observed in $RbMnF_3$ ($S = \frac{5}{2}$) and in related magnetic $Ni^{++}$ flourides.

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| 70-183 | Multiplet Structure in the Reflectance Spectra of Europium Chalcogenides | Lincoln Laboratory, M.I.T. | November 1969 | U | AD 709753 |

Abstract: The ferromagnetic semiconducting europium chlacogenides exhibit two strong reflectance peaks arising from 4f-5d transitions of the $Eu^{++}$ ion which are split by a strong crystal field. The lower peak corresponds to transitions from the $4f^7\ (^8S_{7/2})$ ground state to the $4f^6\ (^7F_J)$ $5d\ (T_{2g})$ configuration, whereas the higher energy peak corresponds to transitions to the $4f^6\ (^7F_J)5d\ (E_g)$ configuration. The structure and polarization of the peaks in a magnetic field are analyzed in terms of the transition probabilities for right and left circularly polarized radiation taking into account (i) the multiplet structure of the $4f^6\ (^7F_J)$ configuration, (ii) the spin-orbit splitting of the 5d level, (iii) a phenomenological exchange field which acts on the 5d electron spin in the ordered phase, and (iv) the Zeeman splitting due to the domain orienting magnetic field.

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| 70-184 | Magnetic and Optical Properties of the High- and Low-Pressure Forms of $CsCoF_3$ | Lincoln Laboratory, M.I.T. | November 1969 | U | AD 709745 |

Abstract: $CsCoF_3$ has hcp (h) and ccp (c) $CsF_3$ layers alternating hhchhchhc at atmospheric pressure (9L structure of $BaRuO_3$) but a cchcch sequence (6L structure of $RbNiF_3$) if quenched from 700°C of pressures greater than 20 kbar. The octahedral-site $Co^{2+}$ ions are between the layers and give the 9L structure a pink color, the 6L structure a lavender hue. The 9L phase obeys a Curie-Weiss law above 70°K with $C_m$=3.7 emu°K/mole and $\theta_p$=62°K. It has $T_N$= 8°K with evidence for a spin-flop transition at $H_c \approx$ 11 KOe and an anisotropy constant $K \approx 5X10^4$ ergs/cm$^3$ at 4.2°K. The 6L phase has $C_m$=3.3 emu° K/mole $\theta_p$=-65°K and is ferrimagnetic below $T_c$=50°K. The magnetization is not saturated at 17.2 kOe and 4.2°K, where $\bar{\mu}$ =0.8 /$Co^{2+}$ is smaller than the 1.23$\mu_B$ /$Co^{2+}$ anticipated at saturation for $RbNiF_3$ -type ordering. Optical data shows a larger trigonal-field splitting for the 6L structure. For both phases, Dq $\approx$ 760cm$^{-1}$, spin-orbit interaction parameter $\zeta \approx$ 500 cm$^{-1}$ and long wavelength cutoff $\approx$ 13$\mu$ m.

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| 70-185 | Theory of Localized vs Band Magnetic Semiconductors | Lincoln Laboratory, M.I.T. | November 1969 | U | AD 709746 |

Abstract: We have considered the question of whether the Hubbard Hamiltonian can lead to properties characteristic of two types of semiconductors, depending on the value of the ratio $\Delta/I$ of bandwidth to intra-atomic Coulomb integral. Ine one type there is a transformation, with increasing T, from a magnetic insulating state to a paramagnetic insulating state, and in the other the system goes from a magnetic insulating state to a paramagnetic metallic state. We have applied a new variational single-determinantal approximation which in contrast to the standard thermal Hartree-Fock approximation duplicates the exact behavior of the model both in the atomic limit, $\Delta/I$ =0, and the band limits, $\Delta I = \infty$ . Limiting ourselves to well-known types of one-electron states, we have obtained stability boundaries as determined

by the free energy between various phases. While the boundaries obtained to date have intrinsic interest, we find that further calculations are necessary to completely answer the question raised above.

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| 70-186 | Onset of Magnetism in Vanadium Oxides: $^{51}V$ NMR Studies of VO | Lincoln Laboratory, M.I.T. | November 1969 | U | AD 709751 |

Abstract: Vanadium "monoxide" $VO_x$ exists over a wide homogeneity range ($VO_{0.79}$-$VO_{1.30}$) in the cubic NaCl structure. With increasing oxygen content or V-vacancy content, its properties progress from weak temperature-independent paramagnetism to a stronger temperature-dependent paramagnetism, and from metallic to semiconducting conductivity. In the present work we have observed the nuclear resonance of $^{51}V$ in small single-crystal pieces of pressure-annealed $VO_{0.86}$, $VO_{1.02}$, and $VO_{1.23}$, using cw and spin-echo techniques in fields of 9-50 kOe at temperatures from 1.4°-300°K. In contrast with previously reported measurements, in no compound was there evidence of a sharp metal-to-insulator transition, and nuclear resonance was observable at all temperatures in all the compounds. A Knight shift of 0.4%, independent of composition and temperature, was observed, while the resonance linewidths increased with increasing susceptibility to a value of 5% of the applied field at 1.4°K in $VO_{1.23}$. These results indicate that the bulk of the temperature-dependent magnetization comes from local moments on a minority of sites whose nuclear resonances are unobservable. These moments, however, cause the broadening of the observed majority-site resonance. A maximum in the transverse relaxation rates observed between 1.4° and 77°K in $VO_{1.23}$ in a a 47 kOe field apparently results from the onset of spin-spin correlations in this range.

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| 70-187 | Optical Properties of the Europium Chalcogenides | Lincoln Laboratory, M.I.T. | November 1969 | U | AD 709755 |

Abstract: The measured optical properties of the Eu chalcogenides are surveyed in an attempt to determine those aspects of the electronic structure of these materials that have been established. Optical absorption as well as optical and magneto-optical reflectivity data

are discussed, along with the results of photoconductivity, photoluminescence and photoemission measurements and of magnetoptical measurements in the vicinity of the absorption edge. It is concluded that the fundamental absorption edge is due to the onset of $Eu^{++}$ 4f to 5d transitions of the type $4f^7(^8S_{7/2}) \rightarrow 4f^6(^7F_J)5d(T_{2g})$ and that a higher energy reflectivity peak is primarily due to $4f^7(^8S_{7/2}) \rightarrow 4f^6(^7F_J)5d(E_g)$ transitions, although anion p-valence band to Eu conduction band transitions may also be involved. The principal unanswered questions involve the relative positions of the Eu 6s and $5d(T_{2g})$ states, the breadth of the 5d levels and the role played by exciton effects in the 4f to 5d optical transitions.

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| 70-188 | Transport Equation for a Fermi System in Random Scattering Centers. II. Independent Electrons in an Arbitrarily Varying Electric Field and Strong Single-Center Potentials | Lincoln Laboratory, M.I.T. | August 1969 | U | AD 709758 |

Abstract: An application of a diagrammatic technique, given by us recently, is made for the calculation of the coefficients of a transport equation for dynamically independent electrons in random impurities. The coefficients of the transport equation are given for arbitrary wavelength and frequency of the electric field (transverse or longitudinal) and strong single-center potentials, but for low impurity concentration.

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| 70-189 | High-Resolution Infrared Spectroscopy with a Tunable Diode Laser | Lincoln Laboratory, M.I.T. | December 1969 | U | AD 709752 |

Abstract: A current-tunable $Pb_{0.88}Sn_{0.12}Te$ diode laser was used to obtain the absorption spectrum of $SF_6$ near the P(16) and P(20) $CO_2$ laser lines at 10.6 m by both direct and heterdyne techniques. Because of its narrow linewidth, the diode laser can perform high-resolution spectroscopy beyond the limits of conventional instruments, moreover, its infared frequency can be tuned continuously over a range much greater than attainable with a gas laser.

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| 70-190 | N-P Junction Photodetectors in InSb Fabrication by Proton Bombardment | Lincoln Laboratory, M.I.T. | March 1970 | U | AD 709748 |

Abstract: N-p junction photovoltaic detectors were fabricated in InSb using proton bombardment to create the n-type layer. At 77K, diodes which were 20 mils in diameter had zero-bias resistances of several hundred thousand ohms. Diode quantum efficiencies near 35% were observed.

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| 70-193 | Seismic Discrimination, Semiannual Technical Summary Report to the Advanced Research Projects Agency | Lincoln Laboratory, M.I.T. | June 1970 | U | AD 710613 |

Abstract: Detailed studies of short-period characteristics of explosive sources on a global basis have been completed. Substantial effort has been expended in the study of propagation path phenomena aimed at the understanding of discriminant capabilities and limitations at low magnitudes. LASA data have been used for several projects involving the detailed characteristics of seismic waves from explosions and earthquakes. A continuous improvement in our data facilities and automatic processing capabilities is reported.

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| 70-194 | The Results of the LES-5 and LES-6 RFI Experiments | Lincoln Laboratory, M.I.T. | July 1970 | U | AD 709766 |

Abstract: This report, a supplement to Lincoln Laboratory Technical Note 1970-3, presents the results of further computer processing by the Aerospace Corporation of LES-6 RFI data taken during the period November 1968 - October 1969.

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| 70-195 | Linearly Polarized Arrays with Almost Isotropic Radiation Patterns | Antenna Laboratory, Dept of Electrical Engineering, Univ of Illinois* | June 1970 | U | AD 711075 |

Abstract: A linearly polarized antenna cannot radiate power uniformly in all directions. However, by controlling the aperture excitation, as is done in an array, it is possible to reduce the maximum gain and approach conditions for isotropic radiation. A numerical method is presented which generates a family of designs which depend on a parameter. As $\alpha$ approaches zero, the radiation pattern tends to become more isotropic. However, the efficiency is reduced and the sensitivity of the pattern to errors in the aperture function is increased. In some cases this sensitivity is so high as to make the result worthless. The design, therefore, must be a compromise between closeness to conditions of isotropic radiation on one hand, and losses and sensitivity to errors on the other. The sensitivity to errors, expressed by the pattern deterioration for a given level or error, has been evaluated by a numerical experiment (Monte Carlo method). A general relation has also been established between the sensitivity and the losses in the antenna. It agrees with the numerical experiment and can be used as a guide to choose the regularization parameter.

*under subcontract to Lincoln Laboratory, M.I.T.

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| 70-196 | On Estimating Explosive Source Parameters at Teleseismic Distances | Lincoln Laboratory, M.I.T. | July 1970 | U | AD 709767 |

Abstract: A study has been made of the short period spectra of five presumed explosions recorded at five arrays. An attempt has been made to relate contrasts in spectra of different events recorded at the same site, to source size; and contrasts observed at different arrays for a given event, to the earth's attenuative properties. Haskell's model for the explosion spectrum was fitted to each event individually after corrections for instrument response and

various exponential attenuations. At a single array, that attenuation which allowed the fitted parameters to vary as dictated by the model was chosen as the correct one. With the attenuation estimated to each array, the spectra observed at all the arrays for a single event are fitted to a source model simultaneously. In most cases the individual and simultaneous fitting schemes yield reasonable values for the source parameters. Haskell's model and the estimated attenuation parameter for a central Asia to LASA path apparently explains a trend in short period spectral ratio measurements as a function of magnitude.

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| 70-198 | Principles of Operation of the Venus Microprogram | MITRE Corporation, Bedford, Mass. | July 1970 | U | AD 709717 |

Abstract: Venus is a computer system comprised of microprograms and software. It is implemented on the Interdata 3, which is a small, microprogrammable computer. This document contains a complete description of the microprogram part of Venus.

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| 70-199 | Tactical Airlift Automation Development/Testbed Experimentation | MITRE Corporation, Bedford, Mass. | June 1970 | U | AD 708722 |

Abstract: The Air Force Electronic Systems Division (ESD) and The MITRE Corporation have established a Tactical Data Systems Development Testbed at ESD to evaluate automation concepts for the control of tactical air operations. The testbed has been used to implement and evaluate a current operations tactical airlift capability.